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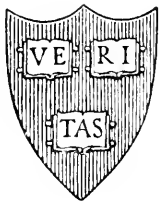

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GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA
HENRY F. NACHTRIEB *State Zoologist*

13.387

SECOND REPORT

OF THE

STATE ZOOLOGIST

INCLUDING A

SYNOPSIS

OF THE

ENTOMOSTRACA

OF

MINNESOTA

ZOOLOGICAL SERIES II

NOVEMBER 1895
SAINT PAUL MINNESOTA

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HENRY F. NACHTRIEB *State Zoologist*

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NOVEMBER 1895
SAINT PAUL MINNESOTA

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CORRIGENDA.

PAGE.

56. In the "key," thirteenth line from top, read **tyrrelli** for **tyrelli.**
73. Seventh line from top, read Herrick for He rick.
95. Second line from bottom, read *americanus* for *Americanus.*
101. Under **Cyclops pulchellus,** supply Plates XXVII, Figs. 4, 5; XXVIII, Figs. 5-8.
105. Middle of page, read m. q. fuscus for m. g. fuscus.
114. Twelfth line from top. read *Cyclopina gracilis* for *Cyclopsina gracilis.*
120. Fourteenth line from top, read lascivus for lascious.
124. Fourth line from bottom, read *Copepoda* for *Copepodæ.*
126. Second line from top, read *Cladocera* for *Cladoceræ.*
129. The last three page numbers of the "key," and the last within the brackets, should read respectively 132, 134, 134, 135.
146. Third line from top, read *Sididæ* for *Sidide.*
148. Third line from bottom, read Sida brachyura for Sida branchyura.
150. Transfer the plate reference under **Latona** to **Latona setifera.**
174. Under **Ceriodaphnia cornuta,** supply Plate LXVI, Figs. 4, 5.
175. Middle of page, read *Rhypophilus* for *Ripophilus.*
195. Eighth line from bottom, read *D. kalbergensis* for *D. kahlbergensis.*
203. Middle of page, read cederstrœmii for cœderstrœmii.
205. Thirteenth line from bottom, read *D. schæfferi* for D. scæhfferi.
210. Near middle of page, read *Macrothrix* (?) *pauper* for *Macrothrix* (?) pauper.
218. Read **Acantholeberis curvirostris** for **Ancantholeberis curvirostris.**
231. Eleventh line from bottom, read *Alona elongata* for *Alono elongata.*
255. Star **Pleuroxus stramineus.**
258. Under **Pleuroxus procurvus,** add LXV, Figs. 6, 7.
260. Under **Leptorhynchus falcatus,** supply Plate LXII, Fig. 17.
266. Under **Polyphemus pediculus,** read LIX for LXIX.
272. Read **Daphnia longiremis** for **Daphnia longiremus.**
273. Read **Ilyocryptus longiremis** for **Ilyocryptus longiremus.**
274. Read **Leydigia quadrangularis** Leydig for **Leydigia quadrangularis Leydig.**
274. Read **Dunhevidia setiger** for **Dunhevidia Setiger.**
293. Fourth line from top, read adductor for abductor.
301. Read **Candona peircei** for **Candona Peircei.**
306. Read **Cypria opthalmica** (Jurine) for **Cypria opthalmica** Jurine.
321. Tenth line from top, read *Cypris gibberula* for *Cypris gibberata.*

Unexplained remain, Plates XXV, Fig. 15; LVII, Fig. 9; LXI, Fig. 5*a*; LXV, Fig. 9. and a few unnumbered figures.

A number of the plate references were supplied from the explanations of plates. A few species are noticed only in the index and the plates.

I am indebted to Professors Birge and Marsh for deciding between the conflicting spellings of names in the manuscript that were not observed until the index was prepared in most cases from the final forms.

I embrace this opportunity to acknowledge the courtesy and good nature of the officers connected with the manufacturing department of the Pioneer Press Company, particularly of Mr. George R. Morrissey.

H. F. N.

LETTER OF TRANSMITTAL.

THE UNIVERSITY OF MINNESOTA.
MINNEAPOLIS, MINN.,
November 30, 1894.

To the President of the Board of Regents of the University of Minnesota.

SIR: I have the honor herewith to submit to the honorable Board of Regents my second report as zoologist of the Geological and Natural History Survey of Minnesota, together with a report on the Entomostraca of Minnesota by Mr. C. L. Herrick, a graduate of the University and professor of Biology at Denison University. The report on one group of the Entomostraca, that of the Ostracoda, was written by C. H. Turner, professor of Natural Science at Clark University, Atlanta, Ga. These gentlemen have given their services to the survey without charge, having asked for and received barely enough to cover their expenses.

Very respectfully, your obedient servant,

HENRY F. NACHTRIEB,
State Zoologist.

BOARD OF REGENTS

OF THE

UNIVERSITY OF MINNESOTA.

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The State Superintendent of Public Instruction.

REPORT

OF THE

STATE ZOOLOGIST

FOR 1893 AND 1894.

Shortly after the distribution of my first report a kindly criticism of the brief reference to the early history of the survey was received from a gentleman who formerly was a resident of Minnesota and took an active interest in the work of the survey. In accordance with the assurance given to the critic I take this opportunity of correcting, so far as possible, the feature which to him seems unjust.

The statement taken exception to is the last sentence of the second paragraph of the "General Introduction," reading as follows: "For many years the Natural History Survey existed only in the wisely formulated law, for which excellent and comprehensive law we owe thanks to Dr. Wm. W. Folwell, who was president of the University at that time."

It is contended that the credit for the survey law is almost entirely due to the Honorable John S. Pillsbury, and "that the truths of history require that those who know the facts should demand that credit be given where credit is due." It is particularly stated that the Honorable A. J. Edgerton, now U. S. District Judge at Sioux Falls, South Dakota, while Railroad Commissioner of Minnesota, discovered there was a balance of a grant of land to the state, called the "Salt Land Grant," and suggested to the Honorable John S. Pillsbury, then a senator from Hennepin county, that this so called salt land ought to be set aside for the survey fund. The suggestion was taken up and after considerable hard work the end was gained in "An act to aid the geological and natural history survey of the state," approved March 10, 1873.

To this I reply: 1. There is no conflict between the bit of history given by the critic and my statement, which alluded only to the original draft of the law creating the survey. 2. My statement was based

upon the published history* of the survey. To this I have never found nor heard of any recorded objection.

Of those who have worked for the interests of the survey the Honorable John S. Pillsbury unquestionably has been the most persistent and unselfish. But with no thought of an historical review the reference to even such bright lights did not occur to me. No one can desire to see honor given where honor is due more than myself, and I trust that, if the published history is wrong and unjust, those who know the facts will publish them.

The disbursement of the funds available during the past two years I shall not tabulate here, as the accountant of the University will give full consideration of that in his report.

During the past year the Survey lost by fire its boats and oars and a few minor pieces of apparatus that were stored in the "Coliseum." The invoice of the Survey property will indicate more specifically the condition of the apparatus.

The field work has been carried on as much as the meagre funds would allow. Special attention has been given to the fishes, the birds and some of the invertebrates.

During June, July and August of 1893, a party of four University students (August Bothe, George D. Head, Frank Manson and Clarence L. Whitman) collected material and data in the Gull lake region. The principal lakes investigated are the following: Gull, Round, Long, Mud, Hubert, Kilpatrick, Upper Gull, the Fishtrap series, Edna, the Cullen series, Mayo, Sibley, Lone, Twin, Pelican, Half Moon, Little and Big Gladstone, Sylvan, Edward, Bass and Mission. The principal streams in this region were also more or less thoroughly investigated.

During the same time another party of four University students (John A. Crecelius, Francis B. Sumner, Clarke Barrows and Charles Topping) were carrying on field work in the region between Park Rapids and the headwaters of the Mississippi. The principal lakes here visited are: Fishhook, the Elbow series, five of the Crow Wing series, Itasca, Elk, Bemidji, Cass and Kitihi.

The material collected by these parties is stored in Pillsbury Hall. Most of the material has been assorted, arranged and catalogued so as to make it readily accessible for study. The fishes of the several collections are being looked over by Mr. U. O. Cox of the Mankato normal school. Mr. Cox is also at work upon a preliminary report

*The History of Geological Surveys of Minnesota, by N. H. Winchell, 1889. Bulletin No. 1 of the Geological and Natural History Survey of Minnesota, page 5.

Final Report of the Geological and Natural History Survey of Minnesota, 1884. Vol. I, page 106.

See also the footnote on page 29 of President Folwell's Inaugural Address, delivered Dec. 22, 1869, and printed immediately after.

on the fishes of the State. This report we hope to have ready for the printer before next spring. It will be issued as one of the bulletins of the Survey.

The ornithologist, Dr. Thomas S. Roberts of Minneapolis, made a trip of ten days into the southwestern part of the State during the latter part of May, 1893, and one of ten days into the Lake Vermillion region during June, 1894. Both trips were very profitable, and demonstrated conclusively that nothing but a visit of the ornithologist to the various important sections of the State at the proper seasons can gain for the Survey the information and material required as a basis for a reliable and satisfactory final report.

The wisdom of prosecuting the ornithological work with a view to a final illustrated report is fully vindicated by the great interest taken in the "Notes on the Birds of Minnesota," published with my first report, and by the numerous inquiries as to when the final report on the Birds of Minnesota is to appear.

The edition of Dr. Hatch's "Notes" is already exhausted. The demand for this publication has been gratifyingly great, particularly in the State, where, I am glad to say, the great majority of the books have found interested owners.

The distribution fund for this report was insufficient, and the last three hundred or more applicants were obliged to pay the transportation charges. The willingness with which these charges were paid has convinced me that all persons really interested in such reports will gladly pay the transportation charges on them. In view of the facts I would suggest that hereafter provision be made to pay transportation charges on only those copies of the reports and bulletins sent to our "exchanges" and to citizens of Minnesota.

During the past summer Mr. C. L. Herrick, a graduate of the University and Professor of Biology in Denison University, with the assistance of Professor C. H. Turner of South Atlanta, Georgia, completed a report on the Copepoda, Cladocera and Ostracoda of the State and tendered it to the Survey for publication. The demand for Mr. Herrick's report on the Crustacea of Minnesota, published in the Twelfth Annual Report of the State Geologist, and the many important and interesting problems connected with this group of animals are a sufficient reason for publishing a revision of the report for 1884. The report will also be of special value to our teachers of zoology.

A few purchases have been made for the museum during the past two years. Of these may be mentioned a young bull moose, two deer, one wolf, one black woodchuck, and several smaller mammals. During the same time the museum has been enriched by valuable donations, of which the following are worthy of special mention:

From Dr. W. S. Strode, Lewistown, Ill., a collection of land and freshwater shells representing about fifty species.

From Nathan Butler, Barnesville, Minn., the bones of a large moose.

From Mr. Benjamin LaMere, Hickory, Aitkin County, a few mammalian skulls and skins.

From Mr. D. D. Stone, Lansing, N. Y., a collection of eleven sets of bird eggs containing forty-two eggs, of which five sets are accompanied with the nests and three sets with the skins of the female birds.

From Mr. Denis Gale, Gold Hill, Boulder county, Colorado, forty-three sets of bird eggs containing one hundred and ninety-seven eggs, of which twenty-two sets are accompanied with the nests. Also the skins of eight birds and three small mammals.

From Mr. James Hobson, Ann Arbor, Michigan, thirty-four mounted skulls, nearly all of them the skulls of different species of birds.

From Mr. A. D. Brown, Pipestone, Minn., three bird skins of special value to us.

From Dr. C. J. Cooke, New Richland, Minn., about one hundred bird skins, the majority of which are from Minnesota.

From Mr. Franklin Benner, Minneapolis, his entire collection of bird skins, eggs and nests. This collection contains about six hundred and fifty skins and represents about two hundred and fifty species.

From Dr. Thomas S. Roberts, Minneapolis, his entire collection of bird skins, eggs and nests. This collection contains eight hundred and fifty skins and represents about three hundred species.

In the Roberts and Benner collections the University has the most complete and perfect collection of Minnesota birds in existence, a collection that makes the ornithological room of the utmost importance to the student of the ornithology of the Northwest.

For the excellence of our ornithological collection we are especially indebted to Dr. Roberts, who was not only the first to present to the University so valuable a collection as his own but was also instrumental in inducing Messrs. Benner, Cooke, and Brown to give us their valuable collections. Dr. Roberts has also given much of his valuable time to the arrangement of the collection since it has become the property of the University. In the tedious work of relabeling and arranging the collection Rev. H. W. Gleason is gratuitously rendering indispensable assistance.

In the field work Mr. Thomas Miller of Herron lake has gratuitously rendered great service to the ornithologist. Several amateur

ornithologists residing in different parts of the State have very generously offered me their assistance in the prosecution of the ornithological work, and it will be a pleasure to properly credit all such assistance in the final report.

All acquisitions are properly recorded in the accession record of the museum, the record containing the accession number, the original number and all known data relating to each specimen, whether purchased, collected or donated.

The ornithological material is recorded in a special record. A card catalogue of all this material is now being prepared, and when completed will make the material readily accessible. Other collections, such as the collection of fishes and insects, will be similarly recorded and catalogued.

It would be unpardonable not to call attention to the cramped condition of the zoological museum at this time. Some of the valuable collections noted above were presented rather reluctantly on account of the insecurity and insufficiency of the quarters. The insufficient protection against fire and the lack of room for proper display of specimens have diverted from us some most valuable material that is now the property of museums in the East. Collectors, and particularly specialists, will continue sending their best and rarest specimens to other museums just as long as we do not offer a safe and adequate depository.

A zoological museum in good quarters and properly taken care of soon acquires material of great general interest and incalculable scientific value,—material that costs more in both time and money to collect and prepare than any other, and that often can not be duplicated at any price. It ought, therefore, be housed in the safest possible building.

The zoological museum in Pillsbury Hall has, without any special effort on the part of the curator, already acquired an amount of material that simply cannot be properly displayed or arranged in the present quarters. Hundreds of fine specimens are crowded into cupboards, drawers and boxes. In this condition the zoological museum must be unsatisfactory to the visitors and discouraging to those in charge of it and desirous of building it up. Moreover, our opportunity to get representatives of those animals which are rapidly disappearing from the State is slipping by.

If the museum is ever to offer a true survey of what the animal kingdom of the State is and was, adequate and safe quarters must be provided very soon.

Very respectfully, your obedient servant,

HENRY F. NACHTRIEB.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA
HENRY F. NACHTRIEB *State Zoologist*

SYNOPSIS

OF THE

ENTOMOSTRACA

OF

MINNESOTA

WITH DESCRIPTIONS OF RELATED SPECIES COMPRISING ALL KNOWN FORMS FROM THE UNITED STATES INCLUDED IN THE ORDERS

COPEPODA CLADOCERA OSTRACODA

By C. L. HERRICK and C. H. TURNER

NOVEMBER 1895
SAINT PAUL MINNESOTA

EDITORIAL NOTE.

Early in the spring of 1894 the state geologist, N. H. Winchell, referred to me a letter from Professor C. L. Herrick containing two propositions, viz.: (1) That the Survey accept and publish the present revision of the report of 1884; (2) that the author be permitted to make such use of the old report as he saw fit and publish the revision independently of the Survey. After having been assured that the errors of the 1884 report had been corrected and the report had been bettered in other respects, it was decided, for reasons that seemed sufficient, to accept the first offer, though the revision had been begun and practically finished without the knowledge of any one connected with the Survey. The manuscript was received during the last week of October, 1894.

The editorial work as well as the proofreading all fell to the zoologist of the Survey. The author's serious illness and his great distance from the University made it impracticable to put any of this work upon him. The work was at times very disheartening, but I did my best, and trust that at least most of the errors and shortcomings of the manuscript have been eliminated.

In justice to the author the following matters deserve special mention:

The author's title, "Synopsis of the Microcrustacea," etc., was changed for reasons found principally in the primary destination of the report and in the usage of some of our best and most generally used text-books of zoology.

For making reference only by author and date the editor is wholly responsible. The date is always an important and often a very essential part of a publication, and for that reason alone is far superior to a reference by a purely artificial number. The superiority of an abbreviated reference to a full or more or less mutilated citation is so obvious that it needs no vindication.

In the bibliography the editor has supplied the number of pages, number of plates and similar data of detail from Taschenberg's *Bibliotheca Zoologica*, *Zoologischer Anzeiger*, *Zoologischer Jahresbericht*, and the *Catalogue of Scientific Papers* compiled by the Royal Society of London. Where these data are wanting the citation could not be found in these publications or could not be identified beyond a doubt. In comparatively few cases could these data be obtained from original sources. More or less gross discrepancies between the manuscript and the publications noted above were very numerous as to date, title

etc. As a rule, these could be satisfactorily cleared. Whenever there was any doubt as to which was correct in part or as a whole, both the author's citation and that of the editor's source were given, the latter parenthetically. Several references made to Strauss have been referred to Straus-Durckheim, and Sars cited with four different sets of initials it seemed clear was intended for George Ossian Sars. A few citations have been added by the editor from original sources. Those interested will not fail to collect others from the *Bibliotheca Zoologica* and similar publications. Under the Cladocera the citations had to be given in the original form, because the data given in the manuscript did not make possible a more definite reference. In these cases all but the references to synonyms were cut out.

In accordance with the rules of nomenclature of the German Zoological Society, the comma between the specific and author's names has been eliminated and all specific names appear in lower case. So far as possible these rules have been followed in other respects. The absence of literature, however, made it unsafe for me to touch doubtful cases.

The "sp. n." of the old report has been replaced by the author's name, Herrick.

The various "keys" have been reduced to a uniform plan, and several of them have been compiled by bringing the sections together from various parts of the manuscript. To increase the value of these "keys," the page upon which the description of the genus or species begins has been added and names of authors and other details have been dropped.

The names of families, genera, etc., have been italicized in the general text.

The order and arrangement of the plates is most unsatisfactory. None of the drawings had been called for by me before they were sent to the engraver, and besides the necessity of using so many of the old plates made an orderly and respectable arrangement impossible.

The index is wholly the work of the editor.

Professor Turner's paper practically appears in its original shape. The key to the Cyprididæ was changed from the bracket form to the paragraph form for practical reasons only.

I take this opportunity to express my indebtedness to Professor C. Judson Herrick of Granville, Ohio, for kindly looking after the engraving and printing of the plates, and to Mr. W. H. Kussmaul of Granville for the care he exercised in the printing of the plates. To the state printing expert, Mr. George C. Stevens, I am indebted for indulgent considerations and a lasting patience.

HENRY F. NACHTRIEB.

April 29, 1895.

PREFACE.

The exhaustion of the edition of "A Final Report on the Crustacea of Minnesota included in the Orders Cladocera and Copepoda" has led to a demand for republication. It has seemed unfortunate that the imperfections of this work, many of them due to the unsatisfactory state of the European literature, while others were the result of imperfect information and faulty observation or hasty judgment, should be perpetuated. The original paper grew out of studies made chiefly while the author was an undergraduate at The University of Minnesota and was very fully occupied otherwise, and circumstances have prevented him from anything but the most casual pursuit of the subject since 1884. It might have appeared that the work had served its purpose, but there were many indications of a need for a comprehensive, synoptical survey of this field, and the present paper seemed the only approximation to such a work. A serious illness, which has greatly impeded the progress of the revision at last decided on, has at the same time made it possible by forcibly relieving the author of more pressing duties. It would have been a great satisfaction to him to have given to the subject the thorough field work and comprehensive bibliographic elaboration it deserves, but strength and opportunity forbid. In default of this it might seem wiser to enumerate only American species, but experience has shown that geographical limitations do not prevail to any great extent in most of the families here considered. In such instances, *Calanida* for example, the attempt has been made to include all valid species and a full synonomy. In the others as full a list is given as is now possible, and while this work may not be alone sufficient to enable the specialist to formulate new diagnoses and descriptions, it yet offers a much fuller synopsis than yet published and will give a bird's-eye view of the taxonomy of the subject.

The most important aspect of the subject, namely, the biological relations of these organisms, has been too generally neglected. In no other group can the problems of parthenogenesis and heterogenesis be so easily and accurately studied. The transparency of the body

makes it possible to examine vital phenomena directly and watch the effects of stimuli upon the circulation, etc., *in continuo*. Many curious problems, among them bathymetric distribution and the effects of environment, can be satisfactorily studied in these groups. It is a matter of wonder that greater use is not made of these types in the laboratory courses of our universities. Probably the chief obstacle has been the lack of suitable means of determining species. This we endeavor to offer in so far as may be necessary for this purpose, but purposely abstain from the theoretical questions everywhere pressing on the attention.

This work claims to be a report on the Crustacea of Minnesota, but it was found impracticable to sufficiently describe our forms without a rapid survey of the whole territory. I am under obligations to Professor C. Dwight Marsh and to Professor E. A. Birge for loan of literature, and to Professor Charles Turner of Atlanta for many notes incorporated in this work. My greatest obligation is to my wife, who has collated the bibliography accompanying. This tedious but most useful labor has been wholly performed by her.

For many incidental aids during the progress of the work I am indebted to my brother, Professor C. Judson Herrick.

The reader is requested to remember that this is a revision, following to a large extent the mould set in 1884, and therefore should not be held to the standard of a work wholly prepared in the light of our present knowledge.

The third part of this paper, that dealing with the *Ostracoda*, is wholly prepared by Professor C. H. Turner, who has been assiduously studying the group for several years, and I feel sure that his contribution will be highly appreciated at the present time, especially as no attempt to monograph the order in America has yet been made.

ALBUQUERQUE, NEW MEXICO, Nov. 1, 1894.

PREFACE TO THE REPORT OF 1884 ON THE CLADOCERA AND COPEPODA OF MINNESOTA.

In presenting what may be denominated a final report of the work done in this state upon the group of Crustacea best represented and, all things considered, most important, the author must admit that the term "final" refers only to his own opportunities and the limitation of time imposed by circumstances.

While a comparatively large proportion of all the species existing within our limits have been examined during the progress of these investigations, there undoubtedly remain many additional and curious forms to reward the search of the student. A great variation in the degree of completeness with which the different genera and species have been treated will be observed, due in part to the circumstances under which they were studied and frequently to the poverty of material. The entomostracean fauna is quite different at different seasons, and a complete knowledge of even our local fauna requires a long period of observation. Even the dead of winter is a favorable time to study some groups. The late autumn is, perhaps, the most favorable opportunity; for then, in one group, the sexual activities are just at their height and both sexes may be studied. A number of Cladocera are restricted to this season. There are a number (how large it is not yet possible to tell) of species in both groups which are to be sought by night, though no phosphorescent species are yet known. Our larger and, especially, deeper lakes have a quite different fauna from the shallow pools and rivers. In general, the flowing waters are poor in Entomostraca. The Cladocera or shelled Entomostraca have here received a large share of attention, and more particularly the Lynceidæ, which are the most minute of Arthropods. This study has been rewarded with an unexpectedly large number of forms, and a particularly large number of species identical with those of Europe and elsewhere. Professor Birge is the only American writer who has attempted this group, and his valuable work has made us familiar with the more striking new species. A few new species are included in our list and several varieties hardly yet known in Europe. The

remarkable Monospilus is among these. This animal has but a single larval eye in the middle of its forehead, and wears its old covering over the newly-formed shell till the latter is a curious patchwork mass. The attempt has been made to incorporate a brief description of all American species with those found in Minnesota, and also to frame keys for the larger genera, so that the place of a species among its congeners may, at least approximately, be found. The difficulty of framing such keys is very great; for few authors have employed the same distinctions in their descriptions, and it is necessary to select points sharply distinctive and conspicuous from the often meager remainder after striking off scattering particulars. In some cases this difficulty has been greatly enhanced by the possibility that some of the species should be considered synonyms or varietal forms. The tendency to combine questionable forms thus produced it was necessary to offset by what may seem a too great conservatism. Faulty, however, as these keys may be, it is hoped that they will serve a good purpose in the extent which they cover. While the limits of this work preclude much more than a systematic outline, opportunity is taken here and there to admit a word on the anatomy or development. Such allusions must be considered simply accidental, for a complete treatment of these subjects would require large volumes, and the material will be long in gathering. A larger proportion of the rare males of the Cladocera are here referred to than in any previous work of equal extent. The genus Cyclops, one of the bugbears to fresh-water carcinologists, is perhaps somewhat summarily treated. The excuse must be the condition of the synonomy. However, most of the combinations made were the result of careful study of large series from different localities. The sketches illustrating this paper are photo printed from the writer's own drawings, and, without the elegance of lithographs, serve the purpose of explaining points of structure which cannot be communicated verbally. I am indebted to Professor A. S. Forbes for very timely aid in bibliography, without which the paper could not have been completed. To Dr. Lindahl, through my friend Mr. Oestlund, I am indebted for a like service. But my obligation is deepest to Professor Rudolph Leuckart of Leipzig, who kindly afforded access to almost a complete set of works on European Entomostraca. Professor C. W. Hall has collected, at much expenditure of time and labor, a set of specimens from different parts of the state, which he kindly placed in my hands, thus enabling me to observe the great similarity of widely-separated faunæ. Mr. Lieberg also sent specimens of Diaptomus stagnalis from saline pools in Dakota.

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PART I

COPEPODA OF MINNESOTA

BY C. L. HERRICK

ORDER COPEPODA.

This extensive order contains minute and predominatingly predaceous animals which constitute no inconsiderable part of the fauna of fresh and salt waters. They serve a beneficent purpose both as scavengers and as providing food supply for the fry of fishes and other aquatic animals.

Copepoda are never inclosed in a bivalved shell, but ordinarily exhibit a more or less elongated cylindrical form, composed of two obvious subdivisions. There are a few species which, by the great prolongation and expansion of some of the tergites or dorsal shields, seem to simulate shelled *Crustacea*. The anterior part of the body, or cephalothorax, is composed of ten somites which are frequently considerably united or fused. Five of these segments constitute the head and bear respectively the following appendages: first, a pair of several- to many-jointed antennæ, which are never primarily sensory in function, although they usually are provided with sense hairs or other like organs; second, a pair of two-branched antennules, which sometimes become almost simple or prehensile; third, a pair of mandibles in the form of masticatory or piercing organs, these being usually provided with a palpus; fourth, a pair of maxillæ of various form and function; fifth, a pair of maxillipeds which not infrequently subdivide in later life to form what appear to be two distinct pairs.

The five thoracic segments have each a pair of swimming feet consisting typically of a two-jointed base and two similar, three-jointed rami. The symmetry is frequently broken by the retardation of the development of the inner or outer ramus, while the fifth pair of feet may become rudimentary and in various ways subserve the organs of sex. The five abdominal segments are nearly devoid of appendages and are continued posteriorly by two caudal stylets which bear strong setæ, constituting, in many forms, a tail-fin or spring.

All *Copepoda*, even such as are, in later life, parasitic, begin their existence as free-swimming nauplii.

Though the vast majority of genera and species are marine, it would seem that fresh-water *Copepoda* make up in the number of individuals what they lack in variety.

As we are dealing primarily with the fresh-water species, no lengthy description of the group is here necessary.

The earlier history of our knowledge of the animals of this order is given by Baird. According to this authority, the first to mention any fresh-water species of this group was Stephan Blankaart,* in his *Schou burg der Rupsen, Wormen, Ma'den, en vliegende Diekens tot Amsterdam.* Leeuwenhoek adds numerous interesting details, and is accredited by Hoek with being the first to discover the relation between the remarkably diverse stages which occur in the history of the *Cyclops.* However, it is evident that he had a very incomplete knowledge of the metamorphoses.

De Geer gives rather characteristic figures of a *Cyclops* in *Memoires pour servir a l'Histoire des Insectes*, vol. vii, 1778.

Mueller, in his great work on *Entomostraca*, adds new facts, defines species and forms the genus *Cyclops.*

Ramdohr, in 1805, gave sundry additions to the knowledge of these animals in his *Beiträge zur Naturgeschichte einiger Deutschen Monoculusarten.* In this work the post-embryonic history is quite fully outlined.

Jurine, in his classic work *Histoire des Monocles qui se trouvent aux Environs de Geneve*, 1820, crystallized what previous authors as well as his own original experiments had brought to light of the anatomy and biology of these animals.

Ferussac (*Memoire sur deux novelles especes d'Entomostraees*) redescribes known species.

Gunner, Stroem, and Viviana seem to have had little effect on the knowledge of the group, though they wrote prior to Jurine.

A recent author attempts to revive the names of Jurine, though hitherto it has been thought hazardous to attempt a specific identification.

The German author, C. L. Koch, who only incidentally studied this group, distinguished more or less perfectly a variety of species which have been reinstated in our literature by Rehberg. Although this proceeding seems quite unjust to the careful authors whose descriptions are recognizable in themselves, the law of priority must probably prevail. Koch's *Deutschlands Krustaceen* appeared in 1838.

Baird's *British Entomostraca*, without greatly extending our knowledge of this order, put in readable form and made available to English readers what was known, and added interesting facts. He distinguished two families of *Copepoda*, (1) *Cyclopidæ*, (2) *Diaptomidæ.* The first included the genera (1) *Cyclops*, (2) *Canthocamptus*, (3) *Arpacticus*, (4) *Altentha:* and the second the genera, (1) *Diaptomus*, (2) *Temora*, (3) *Anomlocera.*

* Latinized *Stephanus Blanchardus.* Hoek recognized *Cyclops brevicaudatus* or *C. bicuspidatus* as the one described, chiefly through knowledge of the present inhabitants of the locality.

Fischer, who contributed not a little to our knowledge of the distribution of fresh-water *Cladocera*, was the next to describe valid species. He described the species found near Moscow and St. Petersburg, Russia.

The justly famous Swedish naturalist, W. Lilljeborg, who has left his mark on so many branches of natural science, has not neglected the microscopic *Crustacea* of his fatherland. *Om de inom Skaane foerekommande Crustaceer af ordningarne Cladocera, Ostracoda och Copepoda*, is the somewhat formidable title of his work, published in 1855. He recognized the following genera of *Copepoda: Diaptomus, Temora, Dias, Ichtyophorba, Tisbe, Tachidius, Harpacticus, Canthocamptus*, and *Cyclops*. A species each of *Diaptomus* and *Canthocamptus* is described, and two species of *Cyclops*. (It would seem from authors' quotations that other species are described in an appendix, but the copy I have seen lacks this.) The author who has done most for micro-carcinology in general is Carl Claus of Vienna. His principal works are:

1. *Das Genus Cyclops*, etc. In *Wiegmann's Archiv für Naturgeschichte*, 1857.
2. *Weitere Mittheilungen ueber die einheimischen Cyclopiden*. The same, 1857.
3. *Die Freilebenden Copepoden*, 1863.

The later work especially is indispensable to the student of *Copepoda*, though in reality it is more important in respect to marine *Copepoda*.

In the meantime a work appeared in Norwegian, with Latin descriptions, from the pen of G. O. Sars. This has been largely overlooked. It is, unfortunately, unaccompanied by plates, but the descriptions bear the stamp of the naturalist.

A little later a second brief contribution from this author was published, but I have not seen it.

Sir John Lubbock in 1863 describes species of fresh-water *Copepoda*, but the publication seems no longer necessary.

Heller, in Tyrol, Fric, in Bohemia, and Uljanin, in Asia, have studied the *Copepod* fauna.

A Russian paper by Poggenpol and Uljanin is quoted as *A Catalogue of the Copepoda, Cladocera and Ostracoda of the vicinity of Moscow*, by Rehberg, and as from the *Protokolle der kais.-naturw. anthropol. und ethnogr. Ges. in Moskau*, but by Cragin, who publishes a translation apparently of the same paper in part, as from the *Bulletin of the Friends of Natural History*.

Hoek, in the *Tijdschrift der Nederlandsche Dierkundige Vereeniging* (*Magazine of the Zoological Society of the Netherlands*), 1875, and later in German in the *Niederländisches Archiv für Zoologie*, gave excellent

figures and descriptions of some species which Claus had too hastily treated.

In 1878 A. Gruber gave descriptions of *Two fresh-water Calanidæ.*

In the same year the first volume of Brady's fine *British Copepoda* appeared. A purely technical work and briefly written, it is yet very comprehensive and in the main reliable. This is a worthy successor of the Ray Society's earliest publication on *Entomostraca*—Baird's great work.

In the sixth volume of the *Abhandlungen d. naturwissenschaftlichen Verein zu Bremen*, Herman Rehberg gives a systematic review of synonomy, and in the revision unites several species in a manner that the present writer had independently been driven to do. It is probably impossible either to substantiate or positively deny some of this writer's identifications of the species of the older authors.

This paper also contains an observation of a hermaphorditic *Cyclops*, which it is interesting to compare with similar anomalies, described by Kurz in *Cladocera.*

In the seventh volume of the same periodical, Rehberg adds to and modifies some of the views expressed above. In the same number is a description of a new species of *Temora* by Poppe. (The same species occurs in the semi-saline waters of the Gulf of Mexico, and had well-nigh gone into print under a new name when this was seen.)

In the above review we have noticed only the more important foreign works on the *Copepoda* and those including fresh-water forms. Dana's magnificent *Crustacea of the Wilkes' Exploring Expedition* is not included, because it is essentially restricted to the marine species, the few descriptions of fresh-water species being quite valueless. Among important contributors to the exclusively marine *Copepoda*, are Boek (*Oversigt over Norges Copepoder* and *Nye Slægter og Arter af Saltvands-Copepoder*), Brady and Robertson, Lubbock and Claus.

The history of the American literature can be quickly traced.

Say described imperfectly an American species of *Cyclops* in 1818. Haldeman describes in volume 7, of the Proceedings of Philadelphia Academy of Science, p. 331, *Cyclops setosa* (which may be *C. serrulatus*). Pickering very imperfectly described a new genus of *Copepoda* from Lake Ontario in Dekay's *Zoology of New York.* This genus is, most likely, *Epischura* of Forbes, and, in strictness, ought to rank it. In 1877 appeared *A List of Illinois Crustacea*, by Professor Forbes, in which two species of *Copepoda* were described which may rank as the first descriptions, at all adequately framed, of American members of the order. In the *Annual Report of the Minnesota State Geologist* for 1878, a brief article by C. L. Herrick outlined, in the light only of the then English literature, the micro-crustacea of Minnesota. No at-

tempt was made to treat the *Copepoda*, but two species of *Diaptomus* are indicated which will prove valid. Occasional papers in the *American Naturalist* and elsewhere follow, till, in July and August of 1882, Professor Forbes added two new genera and several species of *Copepoda*, constituting by far the most considerable addition to the subject yet produced.

In the *Report of the State Geologist of Minnesota for* 1881, C. L. Herrick makes a considerable addition to the knowledge of American *Cyclopidæ*, enumerating ten species, of which six seemed new. This writer also describes a new genus and several new species of *Calanidæ*, some of which unfortunately are identical with those described by Forbes and published about simultaneously.

In April, 1881, V. T. Chambers gave an account of a species of the *Harpacticidæ*, referred by him to *Zachidius*. The species is especially interesting on account of its novel habitat. *Zachidius (?) fonticola* Cham., is found in saline waters of Big Bone Springs, Ky., and is thus very distant from its marine congeners. It is perhaps doubtful if its generic reference can be sustained, but the species is of great interest. The *Diaptomus* described by the same author is not recognizable.

Several articles in the *Naturalist* bring the bibliography up to May, 1883, when F. W. Cragin published in the *Trans. Kansas Academy of Science*, *A Contribution to the History of the Fresh-water Copepoda*. In this paper ten species of *Cyclops* are described or mentioned. The author ignored previous American literature and thus adds somewhat to synonomy. The plates are lithographic, and are carefully, if not artistically, prepared. A valuable feature is the translation of the descriptions of Poggenpol's species from the Russian.

These papers, together with the outline presented beyond, it is hoped, will form a basis for future work.

To the above, which is reproduced without change from the first edition, it may be added that there has been a considerable degree of desultory activity in the study of the *Copepoda* in Europe since the appearance of this work. This has been especially marked in the case of the *Calanidæ*, and, in particular, in the genus *Diaptomus*, in which the confusion resulting from confounding many species under one name has been finally removed and the real specific characters differentiated. Among the most important of these papers are the following: De Guerne and Richard: *Revision des Calanides d'Eau douce:* Brady: *Revision of British species of Fresh-water Cyclopidæ and Calanidæ:* Schmeil: *Deutschland's Freilebende Süsswasser Copepoden.* American literature since 1884 has been but little augmented, the following papers being the only important ones: Herrick: *Contribution to the Fauna of the Gulf of Mexico and the South*, 1887; Forbes: *On Some*

Lake Superior Entomostraca, 1891; Marsh: *On the Deep-Water Crustacea of Green Lake*, 1891; Forbes: *A Preliminary Report on the Aquatic Invertebrate Fauna of the Yellowstone National Park*, 1893; Marsh: *On the Cyclopidæ and Calanidæ of Central Wisconsin*, 1893. (?)

While it is probable that comparatively little remains to be done in the systematic study of North American *Copepoda* except in the west and in mountainous and brackish stations, yet there are few more attractive fields than that offered by the study of the biological conditions under which these forms appear. The processional appearance of several species in the same pool in the spring, the effects of stagnation on the organization, and the peculiar heterogenesis or polymorphism due to age, are all capable of yielding valuable additions to theoretical biology. While much care and attention are requisite, and considerable collateral information, yet the *Cladoceran* studies of Professor Weismann afford a suitable model and inducement. In a purely systematic paper like the present one no attempt can be made to indicate these lines of work.

FAMILIES OF THE FRESH-WATER COPEPODA.

I. Calanidæ. Body elongate; abdomen more slender and quite distinct from the thorax. Antennæ long, 23- to 25-jointed; in the male that of the right side modified for prehension. First four pairs of feet two-branched, outer branch three-jointed. Fifth feet several-jointed, those of the male prehensile; dissimilar on the two sides. Ovisac single. Habit strongly natatory.

II. Cyclopidæ. Cephalothorax compact, ovoid; abdomen slender. Antennæ usually shorter than the cephalothorax, both geniculate in the male, 8- to 18-jointed. Second antennæ (antennules) one-branched. Fifth feet rudimentary, a sixth pair sometimes present, especially in the male. Ovisacs double, lateral. Habit natatory.

III. Harpacticidæ. Body cylindrical or flattened; abdomen not sharply distinct. Antennæ short, not more than 10-jointed, those of the male both geniculate. Antennules palpate. First pair of swimming feet usually prehensile. Fifth feet foliaceous, somewhat dissimilar between the sexes. Ovisac usually single. Habit creeping or sub-natatory.

FAMILY CALANIDÆ.

This group is pre-eminently marine and contains diverse and graceful forms, mostly with very elongated bodies and antennæ. Of the six genera here enumerated as more or less habituated to the use of fresh water, two are found as yet only in America and one is confined to Europe.

Heterocope, namely, is very near *Epischura*, both being restricted to fresh water. *Diaptomus* and *Osphranticum* are likewise only accidentally found in the seas, though their nearest allies are marine. The genus *Limnocalanus* is as yet found in America only in the Great Lakes.

In the distribution of genera we here follow Brady, whose definition of the family *Calanidæ*, including *Calanidæ* and *Pontellidæ* of authors, we quote: "Body elongated; composed of from ten to twelve [obvious] segments. Abdomen nearly cylindrical, much narrower than the cephalothorax and prolonged at the posterior extremity into two more or less cylindrical caudal branches [stylets]. First segment of thorax often anchylosed with the head; fourth and fifth segments also often coalescent. Head only rarely divided into two segments. Anterior antennæ very long and composed of twenty-four or twenty-five joints; that of the right side in the male often modified for grasping [geniculate]. Posterior antennæ large, composed of a basal joint, from which spring usually two branches, the primary branch consisting of two, the secondary of several joints. Mandibles strongly toothed at the apex, palp (usually) two-branched. Maxillæ strong, and provided with a many-lobed palp. Foot-jaws strongly developed: first pair very broad; the basal joints having on the inner margin wart-like processes, from which spring long ciliated bristles; the distal extremity divided into three short joints which are thickly beset with strong and long, ciliated setæ; second pair longer and more slender, basal portion forming two long oval joints; apical portion usually four-to six-jointed. First four pairs of feet two-branched, the outer branches always three-jointed. Fifth pair either like the foregoing, or much modified, unlike on the two sides, and in the male forming clasping organs. A heart is present. Eyes either median and stalked or paired (lateral) and sessile; in the latter case being often coalescent and composed of several lenses. Sexual organs in the female symmetrical, in the male asymmetrical. Ovisac single, borne in front of [below] the abdomen.

The *Calanidæ* are distributed over the whole globe, and yet the limitations of range are much more strict than in the other groups. Thus no species of the eastern continent has been positively identified in America, while the majority of the *Cyclopidæ* of America are old world species or vicarious forms.

Range of altitude is also limited, and the delicate organization of the *Calanidæ* responds to slight changes of the environment. The origin of our fresh-water genera from the marine forms in comparatively recent times is on many accounts very probable. The formation of large inland bodies of fresh water was an essential pre-

requisite, and the limitations of range in themselves point to a more recent origin than the other groups of micro-crustacea; nor is it difficult to trace the connecting links in many cases.

KEY TO THE FRESH-WATER GENERA OF THE CALANIDÆ.

I. Fifth feet of the female bi-ramose.

a. Inner rami of all the swimming feet three-jointed.

* Inner ramus of the right male fifth foot three-jointed.

† Outer ramus of the right male fifth foot two-jointed. **Limnocalanus,** 48

†† Outer ramus of the right male fifth foot three-jointed. **Osphranticum,** 85

** Inner ramus of the right male fifth foot reduced. . . . ***Boeckella.**

b. Inner rami of the first swimming feet two-jointed. . . . **Diaptomus,** 54

c. Inner rami of all the swimming feet two-jointed. . . . . **Broteas,** 80

II. Fifth feet of the female uni-ramose.

a. All the swimming feet with the inner ramus one-jointed.

* Abdomen symmetrical, not prehensile in the male. . **Heterocope,** 80

** Abdomen unsymmetrical, with prehensile appendages in the male. . . . . **Epischura,** 81

b. First swimming foot with one-jointed inner ramus, the rest two-jointed. . . . . **Eurytemora,** 49

c. Swimming feet with three-jointed inner rami.

* Fifth foot of the male one-branched. . . . **Pseudodiaptomus,** 53

** Fifth foot of the male with one-jointed inner ramus. . . ***Poppella.**

GENUS LIMNOCALANUS Sars. 1863.

Cephalothorax six-jointed, slender, last segment never divaricate. Abdomen in the female three- or four-jointed (not including stylets), in the male five-jointed. Caudal stylets elongated with five setæ. First antennæ 25-jointed, shorter than the body; in the right antenna of the male a geniculate joint between segments 18 and 19. Second pair of maxillæ, strong, eight-jointed, last joint unguiculate. Feet bi-ramose, those of the first four pairs with three-jointed rami. Outer ramus of fifth feet in the female three-jointed, with a claw-like process from the second segment; inner ramus like those of the other feet. The outer ramus of the right foot of the male more conspicuously modified, apparently two-jointed, with a long apical claw. This genus very closely approaches *Centropages*, which latter is its marine prototype. The genus is represented by two species, one of which is circumpolar, the other occurring in China farther south.

*Not described by the author. See plates.

(Species preceded by an asterisk have been reported in America.)

* Limnocalanus macrurus Sars.

PLATE I, FIGS. 1–4.

Centropages grimaldii, De Guerne '86.
Limnocalanus macrurus var. auctus, Forbes '87; Sars '62; Nordquist '88; De Guerne and Richard '89; Marsh '92.

The subcylindrical three jointed abdomen is longer than the elongate oval six-jointed thorax. The stylets are very long, spiny and ciliated. Antennæ hardly reaching the penultimate abdominal segment. The claw of the female fifth foot armed with fine, sharp spines. The claw of the male right fifth foot is thick and bears two spines internally. Color generally hyaline. Length about 2.0 mm.

Limnocalanus sinensis Poppe.

De Guerne and Richard '89.

This smaller and rather depauperate form from China may be recognized by the fact that the claw of the fifth foot of the female has strong and irregular teeth and that of the right fifth foot of the male is slender and flexuous. The abdomen is shorter than the thorax. Length 1.65 mm.

GENUS EURYTEMORA Giesbrecht.

(Temorella of Claus, Poppe, Nordquist, Herrick.)

Relatively robust; cephalothorax six-jointed; frontal processes present. Abdomen of the male, five-jointed, of the female, three-jointed. Caudal stylets slender, often very long relatively; apical setæ four, also a similar lateral seta. Antennæ 23- or 24-jointed, about as long as the cephalothorax. In the male 20-jointed with the geniculation between segments 18 and 19. Four pairs of bi-ramose swimming feet, the first pair with a one-jointed inner ramus, the second to fourth pairs with two-jointed inner ramus. Fifth pair of feet in the female simple, similar, penultimate segment produced into a strong hook process; fifth feet of the male uni-ramose, each three-jointed, dissimilar, last joint of the right foot unguiform, of the left expanded.

The genus *Temora* was founded by Baird, to receive one of the *Calanidæ* found abundantly on the English coast and since identified in various places along the shores of the German ocean. Much confusion has existed from the first in the nomenclature of this group resulting, in the first place, from the assumption that the type of the genus *Temora* is identical with *Monoculus finmarchicus* of Gunner, falsely identified with *Cyclops longicornis* of Mueller, and later from the fact that the male of one species has been wedded by our synonomy to the female of a distinct though closely allied form.

Still later it became evident that two sections could readily be distinguished within the genus which have since then been elevated to generic rank by Claus. Both these groups agree in several characters, such as the following: Head distinct from the thorax, fourth and fifth thoracic segments closely united, frequently only the lateral or pleural portions of the latter being evident, abdomen composed of four segments in the male and three in the female, antennæ shorter than the body, 24-(or 25?) jointed, right male antenna geniculate, inner rami of swimming feet, one-or two-jointed, in the female small, in the male prehensile. As restricted by Claus, the genera stand related as shown by the following tabular diagnosis:

Temora.

Antennæ of male 24 jointed, geniculation between joints 18 and 19. Maxillæ and maxillipeds rather large.

First foot with two-jointed inner ramus.

Fifth feet one-branched, the left in the male three-jointed, dactylate, right two-jointed, unguiculate, in the female apparently two-jointed.

Habit, marine.

Sp. 1. *T. longicaudata* Lubbock (=*T. finmarchica* Baird, etc.). Angle of last abdominal segment rounded, left foot of fifth pair in male three-jointed, with a long, immovable process on the first joint, the two remaining forming an apposable clasper, antennæ as long as whole body. (North Sea.)

Sp. 2. *T. armata* Claus. Angle of last abdominal segment produced forward, left foot of fifth pair in the male with the terminal joint expanded into a plate, antennæ reaching *nearly* to end of the abdomen. (Mediterranean.)

Sp. 3. *T. dubia* Lubbock. (As identified by Brady.) Exactly as in *T. armata**, save that the antennæ are said to be *about* as long as the cephalothorax. (Pacific and Atlantic Oceans.)

Eurytemora.

Antennæ 24-(25?) jointed, geniculation between joints 18 and 19. Maxillæ and maxillipeds quite short.

First foot with 1-jointed inner ramus.

Fifth feet one-branched, both three-jointed, the left with an expanded apex, the right with a strong claw, in the female obviously three-jointed, the penultimate segment bearing a strong spine.

Habit sub-marine or fluviatile.

Sp. 1. *E. velox* (Lillg.) Brady (=*T. clausii* Hoek). Penultimate joint of the fifth foot of female with a single spine externally, caudal stylets four to five times as long as wide and feebly spined. (Scandinavian and North European coasts.)

Sp. 2. *E. affinis* Poppe. Last segment of thorax produced. Penultimate segment of fifth foot in the female, with two spines externally, caudal stylets six to seven times as long as wide. Segmentation of last joints of male antennæ more obvious. (Same localities and rivers Rhine, Elbe, etc.) [See below on *T. hirundo.*] Poppe very positively declares *T. clausii* to be identical with the *T. velox* of Lilljeborg, but Claus explains that the male seen by Lilljeborg was *T. clausii*. As identified by Brady, in England, *T. velox* evidently corresponds to *T. clausii*, which should therefore probably yield priority to the older name.

E. affinis occurs very abundantly in rivers and estuaries of, as well as in the Gulf of Mexico.

Sp. 3. *E. lacustris* Poppe. Last segment of thorax rounded. Penultimate segment of fifth foot of female with two spines. Caudel stylets of female about as long as broad. From fresh-water lakes, Holstein, Sweden, Finland, etc.

* The agreement is so close, even in minute details, that a varietal distinction at the utmost seems demanded. See Claus, *Ueber die Gattungen Temora und Temorella*, and Brady, *Challenger Copepoda.*

* Eurytemora affinis Poppe.

PLATES I, FIGS. 5–10; LX, FIGS. 8-15.

Lilljeborg '53 (Temora velox); Poppe '80 (Temora affinis); Claus '81 (Temora affinis); Giesbrecht '81[1] (Eurytemora hirundo).

Form rather robust, about 1.60 mm. long, variously ornamented with colord markings; head separated by an obvious suture from the thorax, rounded anteriorly, with small forked beak; antennæ about as long as the thorax, 24-jointed, the twelve basal joints being quite short and uniform, in the right male antenna geniculated and thickened beyond the twelfth, the geniculation being between the eighteenth and nineteenth, the seventeenth and eighteenth segments furnished with comb like or file-like plate against which plays a similar shorter plate on the nineteenth; the antennules short, three-jointed ramus with twelve setæ, two-jointed ramus with about fifteen; jaw with eight acuminate teeth and a small spine; mandiblar palp with a two-jointed and four-jointed ramus, the former with seven terminal and four lateral setæ; maxilliped very small, six-jointed; first pair of feet with the inner ramus one- the other three-jointed, remaining swimming feet, two- and three-jointed; fifth foot in the female with three joints (apparently four), the basal bearing a single external spine, the second, two external spines and a strong internal process, the terminal joint a long pectinate seta and a small spine; the fifth feet of the male both four-jointed, the right terminating in a long, irregularly excised claw and the left in a fan-shaped expansion with a central spine. The abdomen is five jointed in the male and terminates in two long slender stylets, but sparsely beset with bristles along the inner margin, while in the female the abdomen is three jointed and the shorter stylets are densely spinous and bear numerous fine setæ medianly. The second segment of the abdomen in the female is produced into a spiniferous process with small spines on its sides. The caudal stylets are about six times as long as wide in the female and nearly eight times in the male, the preceding segment being densely covered with short spines in the former, while in the latter there is on either side a cluster of longer stylets. The eggs are carried in a large spherical mass beneath the abdomen as in *Osphranticum* (Potamoichetor). The one-jointed ramus of the first foot bears seven setæ, the terminal joint of the other ramus, five setæ and three spines; the second segment of the inner ramus of second and third feet bears six setæ, its predecessor three, while the terminal segment of the outer ramus carries five setæ, one long, serrated, apical spine and a short external spine; the fourth foot has but five setæ on the apical segment of inner ramus and five setæ, a serarted spine and two small spines upon the opposite branch.

This species was first noticed in America by the writer, in an appendix to his paper in the twelfth annual report of the state geologist of Minnesota. Careful study of abundant material since then shows the identification well-founded, although a few slight differences between this and the north European species can be detected which are by no means so great as the variations in the figures of the several European authors who have described the species. Should it prove that this like other *Calanida* is dimorphous *T. clausii* may disappear and the old name *T. velox* will then be restored for both forms.

Claus is certainly in error in calling the fifth pair of feet four-jointed, as shown by his own figures and especially those of Poppe. Great interest attaches to this find, because it seems to indicate that the same morphological species has arisen under similar conditions in isolated stations. Should the species be found along the Atlantic coast, however, this assumption will be unnecessary.

The curious resemblance, amounting almost to identity, between the *Temora armata* of Claus and Brady's *T. dubia* is likewise instructive, leaving very little doubt of close genetic relationship.

Boeck's description of *T. inermis* is here translated for the sake of completeness. (See *Oversigt over de ved Norges Kyster iagttagne Copepoder;* Vidensk. Selskab. Forhandlinger. 1864, p. 16.):

Length about 1.50 mm., transparent, colorless, with yellow viscera and a yellow band on the posterior part of the head and another upon the first segment of the abdomen. The body greatly elongated, slender. Head divided by a transverse suture into two parts, likewise the fourth and fifth segments distinctly separated. The fifth segment in the male rounded, in the female accuminated. The first joint of the abdomen in the male, but the middle one of the female, the shortest. The caudal appendages elongate, but shorter upon the abdomen of the male. The outer seta attached nearer the middle than the end of the caudal stylets. The anterior antenna of the male is strongly swollen in the middle and is armed with small spines upon the eighth to the twelfth joints. Last foot of the female two-jointed, first segment short; second longer, oval, provided on the outer angle with a spine, on the inner with a longer curved spine-like process, at the apex is a long, straight spine. The fifth legs of the male are three-jointed; second joint of left limb shortest, the third expanded at the end; first joint of the right foot long, but less broad; spines on the inner angle very small; third segment rather longer and provided at the end with simple teeth.

The *Temorella* (*Eurytemora*) *hirundo* of Giesbrecht differs from *T. affinis* only in three very significant particulars: first, the body is more slender; second, the caudal stylets are considerably longer; third, the

last segment of the thorax is rounded instead of acute, and bears minute bristles. The close agreement of the other parts suggests a local race or variety, but it may be best to retain the name notwithstanding.

GENUS PSEUDO-DIAPTOMUS Herrick.

Resembling *Metrida* and *Diaptomus;* compactly framed; cephalothorax six-jointed, last two segments coalescent above; head rounded in front, beaked; eye small; antennæ appearing 22 jointed in both sexes, longer than the thorax; the right male antennæ geniculate as in *Diaptomus;* antennules bi-ramose, both rami rather short, inner one seeming but two or three-jointed; mandible ten-toothed; maxillipedes well developed; feet all bi-ramose save the last, both rami three-jointed; first feet smaller; fifth feet with inner ramus obsolescent, in the male nearly as in *Diaptomus*, in the female rather slender, simple, three-jointed; abdomen in the female three jointed, in the male five-jointed; stylets in the female longer; ovisac single; spermatophore pear-shaped, liable to be mistaken for eggs.

* Pseudo-diaptomus pelagicus Herrick.

PLATE I, FIGS. 11-17.

Herrick, '84 and '87.

Rather compact; thorax alike in the sexes, antennæ short, seeming 22-jointed; first foot small, both rami three-jointed; fifth feet in the male with but small rudiments of the inner rami, basal portion heavily armed with short teeth, otherwise almost as in *Diaptomus;* fifth feet of female slender, alike; abdomen in male very slender, with short stylets armed with five terminal setæ and a series of bristles on the inner margins, distal margin of segments of abdomen toothed; a series of spines also ornaments the middle of the first segment below; abdomen of female short and very spiny, first joint thick, second slender, oblong, third joint short; length of abdomen supplemented by that of the elongated stylets, which are spinulous on the edges; ovisac ovoid, eggs numerous; opening of operculum vulvæ with lateral projecting lips.

This species is ornamented with irregular markings of brownish color which gives it a strange appearance not observed in any other *Copepod.* The size is like *Temora velox*, which the female resembles a little, a resemblance enhanced by the elongated stylets.

This genus affords an illustration of a "missing link" connecting the fresh-water genus *Diaptomus* with its fellows of the sea. In most respects the species closely resembles *Diaptomus*, while in others it approaches *Drepanopus*, and in still others *Euchæta.* The entire reduc-

tion of the inner branches of the fifth feet in both sexes is especially remarkable in view of the three-jointed inner rami of all the other feet. The fifth foot in the male is exceedingly like that of *Drepanopus pectinatus* Brady, while those of the female are on the same numerical plan; in that genus, however, the male antenna is not geniculate and the first foot has the inner ramus one jointed. The genus *Euchata* is a somewhat miscellaneous assemblage, with some species resembling *Pseudo diaptomus*. In some respects *Centropages* is likewise similar.

GENUS DIAPTOMUS Westwood. 1836.

Cyclopsina—Milne-Edwards.
Glaucea—Koch.
Pontic—Ouchakoff.

Cephalothorax composed of seven segments, of which the cephalic two are more or less closely fused to form the head. Abdomen narrow and shorter than the thorax, with three obvious segments in the female and four in the male, the last bearing two short stylets. Each caudal stylet is armed with five sub equal plumose setæ and one smaller internal bristle. Antennæ of the first pair long, 25 jointed; in the male geniculate between the eighteenth and nineteenth joint and variously thickened and armed, the penultimate segment often provided with a curved hook. Second antennæ (antennules) two-branched; the exterior branch seven-jointed and bearing apically several long setæ, inner ramus shorter and two-jointed. The mandibles armed with about nine acute teeth and provided with a bi-ramose palp. The maxillæ of the first pair are very short and armed with closely set setæ. The second maxillæ, or maxillipeds, are long and directed cephalad, seven-jointed. The first pair of swimming feet has a two-jointed inner ramus while each of the three pairs following has both rami three jointed. The fifth pair of feet are dissimilar between the sexes and furnish the most important specific characters. In the female the two feet are alike and the inner ramus is reduced or rudimentary, often one jointed. The external ramus develops a strong claw from the penultimate joint, while the small apical segment bears one or more small spines. The fifth feet of the male are dissimilar, five jointed, the inner rami rudimentary, the right limb having a long apical claw on the outer branch.

The species are generally slender and graceful, the antennæ often exceeding the body in length. Some forms are brilliantly colored while most are pellucid. Perhaps most of the species are found in open lakes, but a number are restricted to swampy localities and others are limited to early spring or late fall and stand in such close relations to other species as to strongly suggest a sort of heterogenesis like that we have demonstrated in *Cyclops*.

The American literature has been unfortunate in respect to this genus, chiefly because the European species were so imperfectly described that satisfactory differentiation was impossible. Within the last few years this difficulty has been removed, and the work of De Guerne and Richard has laid the foundation for careful discrimination. It is thought advisable to reproduce the essentials of the descriptions of the known species so that other students may have the means of identifying our species, only a small part of which are as yet satisfactorily known.

KEY TO THE GENUS DIAPTOMUS.

I. Male with a hooked appendage on the last joint of the right antenna. . . . . **asiaticus,** 56; **denticornis,** 56.

II. Male with a serrated plate on the antepenult segment of the right antenna. . . **serriconis,** 56; **wierzejskii,** 57; **pectinicornis,** 57; **trybomi,** 57; **hircus,** 57.

III. Male with the appendage of the antepenult segment of the antenna prolonged into a curved hook longer than the penultimate segment. . . . . **ciseni,** 58; **franciscanus,** 58.

IV. Male with the appendage of the antepenultimate joint of the antenna straight, and as long as or longer than the penultimate joint.

a. The basal joint of the right foot of the fifth pair in the male with an external accessory process. . . . . **salinus,** 59; **laticeps,** 59.

b. The basal joint of the right male fifth foot without a process. . **minutus,** 59; **ashlandi,** 60; **sicilis,** 60; **baccillifer,** 61; **shoshone,** 61.

V. Male with the appendage of the antepenultimate joint of the antenna shorter than the penultimate joint.

a. The first segment of the abdomen unsymmetrical, with a strong process upon the right side. . **signicaudatus,** 63; **incongruens,** 63; **gibber,** 63.

b. The antepenultimate segment of the antenna of the male with a hyaline appendage along its outer margin.

* Inner ramus of the right fifth foot of the male shorter than the basal segment of the external ramus. . **zachariasi,** 64; **leptopus,** 64.

** Inner ramus of the right fifth foot of the male longer than the basal segment of the outer ramus. . . **tatricus,** 65; **coeruleus,** 65.

c. The antepenultimate segment of the right antenna of the male without a straight lamina.

* The process of that segment very short and obtuse. . . . **gracilis,** 66.

** The process of the antepenultimate segment of the right male antenna long and pointed.

† Inner ramus of the left fifth foot of the male shorter than or nearly equal to the basal joint of the outer ramus. . **orientalis,** 66; **stagnalis,** 66; **albuquerquensis,** 67; **lintoni,** 68.

†† Inner ramus of the left fifth foot longer than the basal joint of the outer ramus. . . . . **siciloides,** 69; **novamexicanus,** 70; **sanguineus,** 71; **minnetonka,** 71; **armatus,** 72.

VI. Male with the antepenultimate joint of the right antenna not armed with hook or plate.

a. Internal ramus of the right male fifth foot longer than the basal joint of the outer ramus.

* Internal branch of right fifth foot of the male one-jointed. **oregonensis,** 72; **pallidus,** 73; **piscinæ,** 74; **laciniatus,** 74.

** Internal branch of the right fifth foot of the male two-jointed. . **castor,** 74; **glacialis,** 75; **mirus,** 75; **sancti-patricii,** 75.

b. Internal ramus of the right fifth foot of the male shorter than the basal joint of the outer ramus.

* This internal ramus greatly expanded. . . . . **lilljeborgi,** 76.

** Inner ramus of the right fifth foot of the male not enlarged.

† Abdomen asymmetrical. . . **roubaui,** 76; **tyrelli,** 76; **theeli,** 77; **lobatus,** 77; **affinis,** 77; **amblyodon,** 78; **mississippiensis,** 78. (D. birgei, 79.)

Diaptomus asiaticus Uljanin.

PLATE X, FIG. 7.

Uljanin '75; De Guerne and Richard '89.

This seems to be a curious depauperate form found by Uljanin in the desert of Kisil-Kum, Siberia. The peculiar form of the fifth feet of the male together with the hook at the extremity of the right male antenna serve to distinguish it. Length of female, 1.76 mm.; of antennæ, 1.31 mm. Color, red.

Diaptomus denticornis Wierzejski.

PLATE X, FIG. 4.

Sars '63 (castor); Wierzejski '82 and '83 (gracilis), and '87.

This is one of the large species (3.0 mm. long). It was identified by Sars with *D. castor*. Although originally found in Scandinavia, it appears to occur in suitable stations throughout Europe. The antennæ are short, scarcely exceeding the third abdominal segment. The last segment of the right antenna of the male hooked, the penultimate segment with a hyaline plate. The figures illustrate the characters of the fifth feet.

Diaptomus serricornis Lilljeborg.

PLATES VIII, FIG. 14; IX, FIG. 12.

Lilljeborg '88; De Guerne and Richard '89.

A species of moderate size 1.80 mm. long, characterized by the fact that the antepenultimate of the right male antenna bears a projecting plate furnished distally with coarse teeth. The fifth feet of the male are also characteristic. The last thoracic segment bears small spines laterally. The caudal stylets about equal in length the two preceding segments combined. The antennæ in the female nearly reach the end of the stylets and are said to be 23-jointed. The species was found in lakes of the Russian tundras.

Diaptomus wierzejskii Richard.

PLATES VIII, FIG. 4; IX, FIG. 13.

Richard '88; De Guerne and Richard '89.

A rather large species which is obviously very near, if not a variety of *D. servicornis*. The caudal stylets equal the preceding segment. The antennæ do not exceed the second abdominal segment and in the male are armed as described above. The internal rami of the fifth feet of the female are one jointed. The species has been encountered in Spain and Saxony. Length 2.75 mm.

Diaptomus pectinicornis Wierzejski.

PLATE X, FIG. 3.

Wierzejski '87; De Guerne and Richard '89.

This species can only be separated with difficulty from the other members of this section. Making some allowance for the different positions and distortions assumed under the microscope some divergence is to be expected. The caudal stylets are a little longer than the preceding segment. Antennæ reach to the stylets. The dentate plate on the antepenultimate segment of the right male antenna has about fifteen strong teeth on its distal half. 1.8 mm. long.

* **Diaptomus trybomi** Lilljeborg.

PLATES VIII, FIG. 17; IX, FIG. 4; X, FIG. 13.

De Guerne and Richard '89.

This is a very peculiar and easily distinguished species. It has but a few minute denticulations at the extremity of the appendage of the antepenult segment of the male antenna, but, in strictness, must fall into the present section. Rather small (1.5 mm.). The last thoracic segment with a dorsal projection which extends toward the right side. The first abdominal segment in the female also has a large dorsal process. The caudal stylets are short. The antennæ almost reach the base of the stylets. The form of the feet may be gathered from the figures. Oregon.

Diaptomus hircus Brady.

PLATE XXXIII, FIGS. 6-8.

Brady '91.

FEMALE.—Seen from above the body is widest in front, thence tapering backwards to the hinder end of the thorax, which is a little wider than the abdomen. The posterior thoracic angles are mucronate but not very strongly produced. The anterior antennæ reach backwards as far as the posterior end of the thorax. Inner branch of

fifth foot two-jointed, more than half as long as the first joint of the outer branch, its apex clothed with a fringe of minute cilia; second joint of the outer branch ending in a stout, slightly curved claw, which is slightly ciliated on the concave margin; last joint bearing at its apex a long, finely ciliated spine and one much smaller seta.

MALE.—Antepenultimate joint of the right antenna armed with a plow-share shaped process, which is nearly half as long as the following joint, and has an obscurely fimbriated free margin. Inner branch of the fifth foot on the left side very small; outer branch slender, ending in two subequal finely pectinated setæ; the last joint of the protopodite has a finger-like hyaline appendage on the inner margin, and there is a similar but smaller organ in the same position on the right foot. Inner branch of the right fifth foot very small, pyriform, one-jointed, acuminate; terminal claw of the outer branch long, slender, subsigmoid. Length 1.1 mm.

* **Diaptomus eiseni** Lilljeborg.

PLATE X, FIG. 11.

De Guerne and Richard '89.

One of the largest species known. First segment of abdomen with lateral spines. Caudal stylets short, hairy. Antennæ short, reaching the lateral processes of the abdomen. Antepenultimate segment of right male antenna with a hooked process reaching beyond the end of the antenna. Inner ramus of the fifth foot of female obscurely two-jointed. The fifth feet of the male very unequal, inner rami two-jointed: basal joint of the right foot provided with a spiny process. Length 4.0 mm : male 3.5 mm. This form is about the size of *D. stagnalis*, but seems quite distinct: it was found at Centreville, Cal.

* **Diaptomus franciscanus** Lilljeborg.

PLATE VIII, FIGS. 12, 16.

De Guerne and Richard '89.

A species of moderate size (2.3 mm.). Last segment of the thorax obtuse with minute spines. First segment of abdomen about as long as the rest of the abdomen, spined laterally. Second abdominal segment very short. Caudal stylets short. Antennæ reaching to the stylets, 25 jointed. The hook-like process of the antepenultimate joint of the male antennæ a little longer than the penultimate joint. The form of the fifth feet chiefly separates this species from *Diaptomus similis* Herrick. Collected in the vicinity of San Francisco, Cal., by G. Eisen.

Diaptomus salinus Daday.

PLATE VIII, FIG. 3.

Daday '85[5]; De Guerne and Richard '88[1] (D. blanchardi), and '89.

This species was found by Daday in Forda, Hungary, and is identified with the form subsequently described by De Guerne and Richard as *D. blanchardi*. It may be recognized by the sharp spines on the right side of the first and second segments of the abdomen (affording a transition toward *Heterocope* and *Epischura*), and also by the peculiar armature of the male fifth feet, which have accessory processes upon the basal joint of the right limb and the second segment of its outer ramus. The apical segment of the outer ramus of the fifth feet of the female are unusually well developed. The antepenultimate segment of the male geniculate antenna has a very long straight process, longer than the two following segments. Length of female 2.2 mm. The very short antennæ and saline habitat further distinguish it.

Diaptomus laticeps G. O. Sars.

Sars '63; De Guerne and Richard '89.

This species, which is widely distributed in Europe, has the front considerably dilated. The antennæ are as long as the body. The caudal stylets as long as the two preceding combined. The antepenultimate of the geniculate antenna has a process shorter than the penultimate segment. The male fifth foot has armature similar to *D. salinus*. Length 1.5 mm.

* **Diaptomus minutus** Lilljeborg.

PLATE VIII, FIG. 9.

De Guerne and Richard '89; Marsh '92 and '93.

One of the smallest species of the genus, originally taken in Greenland, but widely distributed in the northern regions. Slender, with the greatest width behind the middle. The fourth and fifth thoracic segments fused or more or less distinct in the old, with small mucronate lateral lobes. First segment of the abdomen as long as the remainder, expanded anteriorly and armed with small spines. Second and third abdominal segments partly fused, the second very short. Caudal stylets twice as long as broad. Antennæ 25-jointed, somewhat longer than the stylets. Antepenult segment of male antenna with a long slender process, nearly as long as the two following segments and slightly hooked at the tip. The external ramus of the fifth foot of the female is two-jointed, with a short claw, the inner ramus is small and one jointed. The left fifth foot of the male is much shorter than the right, and its apical segment is armed with a spiny pad and

two larger spines; the inner ramus is of moderate size. The inner ramus of the outer leg is obsolescent. The accessory spine of the outer ramus is near the middle of its segment. Length 1.0 mm.

Marsh finds this form in Green lake and the Great Lakes; it may, therefore, be expected in Lake Superior in Minnesota.

* Diaptomus ashlandi Marsh.

PLATE VI, FIGS. 4-6.

Marsh '93.

"A small pelagic species closely resembling *D. sicilis* Forbes. In form it is slender, hardly to be distinguished from *D. sicilis* and *D. minutus*. The first joint of the abdomen in the female is longer than the remaining part of the abdomen, is dilated at the sides and bears two minute lateral spines. The second and third joints are so closely united that the abdomen appears two-jointed. The furcal joints are about twice as long as broad. The antennæ reach just beyond the furca. The right antenna of the male is much swollen anterior to the geniculating joint, and bears on the antepenultimate an appendage slightly exceeding in length the penultimate joint. This appendage may be blunt pointed or slightly enlarged at the extremity. The fifth feet of the female are rather slender: the outer ramus is two-jointed. The third joint is represented by two short spines. The inner ramus is one-jointed, a little longer than the first joint of the outer ramus, armed at the tip with two rather long spines.

"The feet of the male are slender. The basal joint of the right foot is about twice as long as that of the left. The first joint of the outer ramus is a little wider than long. The second joint is wider at the inner than the outer end; the lateral spine is stout, curved, situated near the inner end. The terminal hook is slender and falciform. The inner ramus is slender, one-jointed, and about one-third longer than the first joint of the outer ramus. The left foot extends a little beyond the first joint of the outer ramus of the right. The second joint of the outer ramus has three blunt spines upon its apex and is armed with minute bristles within. The inner ramus is slender, one-jointed, and reaches about half the length of the second joint of the outer ramus. Length of female 0.97 mm.; of male 0.89 mm."

This is a pelagic species found in Lake Superior and others of the Great Lakes, and consequently occurs upon the shores of Minnesota.

* Diaptomus sicilis Forbes.

PLATES V, FIGS 1-7; XIII, FIG. 18.

Herrick '83 and '84; De Guerne and Richard '89; Forbes '91; Marsh '93.

The discrepancies respecting this species as described by various authors must be due to heterogenesis. It varies greatly in size and armature of the feet. The form is slender and graceful and very like

D. pallidus, from which it differs in possessing a hook on the right male antennæ. The antennæ exceed the caudal setæ and are very slender; that of the male on the right side bears a curved plate or hook which in my specimens is decidedly shorter than the following joint, though said to be equal to it by De Guerne and Richard. The fifth feet of the female resemble those of *pallidus*. The inner rami of the male fifth feet are two jointed in the type, but both Marsh and I find forms with one-jointed rami. The terminal claw of the right foot is long and geniculately curved, the accessory spine of the preceding segment is near the distal one-third, the inner ramus is (in our form) quite slender, longer than the basal segment of the outer ramus. The terminal joint of the left foot is rounded and ciliated, as well as furnished with two spines. Length of larger forms 1.4 mm., male considerably less. Our small form is 1.1 mm. long and may prove a subspecies, though agreeing with Marsh's figures. Compare also *D. siciloides*, the western representative of this small form.

Diaptomus baccillifer Koelbel.

PLATE X, FIG. 2.

Wierzejski '82 (D. gracilis var. d and b); Koelbel '85; Wierzejski '87 (D. montanus); De Guerne and Richard '89.

A small species encountered in high latitudes and altitudes of the old world, Siberia and the Alps being the chief stations, is not well distinguished from its allies. The antennæ reach the stylets, and in the male the geniculate antenna has a strong process on the antepenult joint. The internal rami of the fifth feet are more or less distinctly two-jointed, being very short in the female. The inner ramus of the left foot in the male is fused with the preceding segment, and near its base is a spine. The outer ramus of the same foot is forcipate. Length 1.0 to 1.5 mm.

* **Diaptomus shoshone** Forbes.

PLATE V, FIG. 11.

Forbes '93.

"A very large and robust species. Thorax broadest in front, across the maxillæ, tapering gradually, with little convexity to the posterior third. In the female the angle of the last segment is bifid, both projecting points being minutely spinose at the tip. The first segment of the abdomen is laterally expanded; the expansion of the left side with a minute spine at the apex behind; that on the right produced at the same point into a small, rounded tubercle, 0.03 mm. in length, about as broad as long, making this first segment somewhat unsymmetrical." "Egg mass very large, obovate (narrowest forward). Right antenna of male robust, the last two joints without special appendages, antepenultimate with a long inarticulate process at its outer apex, extending beyond the tip of the penultimate and to

the middle of the last segment. The margins of this process are smooth, but it is broad and emarginate at the tip. The fifth pair of legs of the male resemble the corresponding appendages of *D. stagnalis*, but differ notably in detail. The left ramus of the right leg is borne at the inner terminal angle of the second joint, is longer than the joint following, is armed at the apex with a few small acute spines, and bears upon its outer margin, near the tip, a broad fascicle of delicate hairs. The basal joint of the outer ramus is two-thirds the length of the second joint of the peduncle, and without hairs or spines of any description. The second joint of this ramus is about equal in length to the second joint of the peduncle, and bears at its outer margin, close to the tip, the usual stout seta, which is two-thirds as long as the joint to which it is attached. The terminal claw is not regularly curved, but is nearly straight for the basal three-fourths. The left leg is bi-ramose, the inner ramus straight, slender, extending about to the middle of the second joint of the outer, and armed at its tip. The second joint of this ramus is as long as the first, if measured from the tip of the apical spine. This spine, seen from behind, is stout, conical, rather blunt, and has opposed to it within, projecting from the inner angle of the segment, a stout, curved seta, slightly plumose on its distal half. Between these, but more closely applied to the outer spine, is a hemispherical cushion like elevation, set with small, short spinules. On the basal half of the inner margin of this terminal segment is also a much larger hemispherical cushion, but with longer and more slender hairs, while the terminal half of the inner margin of the segment preceding is also moderately inflated and covered with delicate hairs. The antennæ of the female are 25 jointed, as usual, and reach to the base of the abdomen. The legs of the fifth pair closely resemble those of *stagnalis*, but have the terminal setæ of the inner ramus much less developed. This ramus is a little shorter than the basal joint of the outer ramus, and about half its diameter. It bears at its tip two stout setæ equaling the ramus itself in length, plumose under a high power, and has, in addition at its inner tip and on the margins adjacent, a patch of delicate hairs and spines. The second joint of the outer ramus is as long as the first, if measured from the tip of its terminal claw. The latter is nearly straight, very slightly recurved. This joint bears a single spine at its outer distal angle, just within which is the rudiment of the third segment of the ramus, which bears two spines similar to the above, the inner of which is the longer, the outer itself being longer than the adjacent spine of the second joint. Adults of both sexes are blood-red throughout, except the egg sac of the female, which is purple." Length of female, including setæ, 3.1 mm.; male, somewhat smaller. In various lakes in Yellowstone Park.

* **Diaptomus signicaudatus** Lilljeborg.

PLATES VIII, FIG. 13; IX, FIG. 10.

De Guerne and Richard '89.

A small species found at great altitudes in the Sierra Nevada Mountains of California and forming an obvious transition toward *Epischura*. Form rather robust, greatest width at the second segment. Last two segments of the thorax confluent, projecting into lateral lobes bearing small teeth. The fourth thoracic segment with a slight dorsal gibbosity. First abdominal segment expanded and spined anteriorly, and bearing a large retrorse process on the right side posteriorly. Second segment short. Caudal stylets about half again as long as wide. Antennæ 25-jointed, extending little beyond the stylets. Antepenult segment of the right male antenna with a small hook. Fifth foot in the female with one-jointed inner ramus as long as the basal joint of the outer ramus. The terminal segment of the outer ramus is obsolescent. The external ramus of the right foot of the male bears a hyaline lamina on the inner aspect of the basal segment. Second segment more than twice as long as the preceding. Claws simply arcuate. Accessory spine nearer the end than the base of the second segment. Inner ramus wide and acute, shorter than the basal segment of the outer ramus. The left foot has a slender inner ramus, longer than the basal segment of the outer, whose apical joint is pilose and armed with two spines. Length of female 1.5 mm.; of male 1.3 mm.

Diaptomus incongruens Poppe.

PLATE VIII, FIG. 6.

Poppe '88; De Guerne and Richard '89.

A Chinese species of moderate size, characterized by the fact that the projecting angles of the last thoracic segment are dissimilar on the two sides and the possession of a broad mucronate process on the right side of the first abdominal segment. The antennæ extend far beyond the stylets. The antepenult joint of the right male antenna bears a hyaline lamella ending distally in a small hook. The fifth foot of the female has a one jointed inner ramus as long as the basal joint of the outer ramus. The apical joint is distinct and the claw serrate. The inner ramus of the right foot of the male is one-jointed and that of the left foot two jointed. The terminal segment of the outer ramus of the left foot has two spines apically and a ciliated plate within. Length of female 1.4 mm.

Diaptomus gibber Poppe.

PLATE VIII, FIG. 1.

De Guerne and Richard '89.

A decidedly unique form from Brazil. The last thoracic segment forms on either side a bi spinose process, the two being dissimilar. The first segment of the abdomen is expanded proximad and bears on

the right side distally a broad blunt process. Antennæ reaching the caudal setæ; that of the male on the right side bearing a lamella and hook on the antepenult segment. Inner rami of fifth feet in the female two-jointed, outer ramus three-jointed. The inner rami of the fifth feet of the male are curiously modified, and we must refer to the figures.

Diaptomus zachariasi Poppe.

PLATE X, FIG. 6.

Poppe '86; De Guerne and Richard '89.

A species closely resembling *D. leptopus* and found in Silesia. While the last segment of the abdomen is not dilated it is ornamented with two spines. The inner ramus of the fifth feet of the female is two-jointed and armed at the apex with three spines, and is somewhat longer than the basal joint of the outer ramus. At the base of the claw of the outer ramus is a strong tooth. The apical segment is distinct and bears two spines. The figures of the male foot are not entirely satisfactory, but the inner ramus of the right leg is said to be rudimentary, short and two-jointed, while that of the left leg is one-jointed but quite long. The apical joint of the left foot is forcipate. The antepenult segment of the male antenna has a hyaline plate which is scarcely hooked distally. Length of female 1.8 mm. Like our *D. leptopus* this species is brilliantly but variously colored.

* **Diaptomus leptopus** Forbes. 1882.

PLATES II; IX, FIG. 9.

Forbes '82; Herrick '84 (D. longicornis var. leptopus); De Guerne and Richard '89; Marsh '93.

This species, which is one of the commonest in small lakes in Minnesota, is widely distributed in the Mississippi Valley. While not large it is generally ornamented with brilliant coloration bands, of which the purplish suffusion of the tip of the antennæ and abdomen are most constant. Marsh found it of a brownish red color much as *D. sanguineus*. We find it during the summer quite pellucid except for the purple markings. The body is stout with the head and last two thoracic segments fused. The last thoracic bears on either side one or two small spines. The abdomen is short, the last two segments being fused; the first segment bears a small lateral spine on either side. The female antennæ do not extend to the end of the caudal setæ and their spines are short. The right male antennæ is strongly geniculate and spined. The antepenultimate segment bears only a very inconspicuous hyaline lamina but no hook or process as stated by Forbes and by De Guerne and Richard. The fifth foot of the female is short, with an inner ramus scarcely shorter than the antepenultimate segment of the outer ramus and bearing at the tip two subequal spines and a cil-

iated process. We do not find in this species that the claw of the penultimate segment of the outer ramus is denticulate, though in some stages or forms it may be. The apical segment is obsolescent and bears two unequal spines. De Guerne and Richard figure an accessory spine at the base of the apical segment. There is occasionally a slight tendency for the inner ramus to appear obscurely two-jointed. The male feet of the fifth pair are very long. The inner rami are both rather long (longer than the segment of the outer ramus opposite which they stand), one-jointed, and slightly ciliated apically. The terminal claw of the right foot is short and slightly curved and denticulate toward the apex interiorly. The preceding segment has a short accessory spine. The segment bearing the two rami has a short spine laterally and is bristly exteriorly. The terminal segment of the outer ramus bears two spines and a few cilia, while the penultimate segment has a ciliated process inwardly near its apex. The armature of the third and fourth feet is similar, the apical segment of the outer ramus bearing an external short spine, one long spine and two setæ at the tip, and three setæ internally. Length of female 1.5 to 1.7 mm.; of male 1.4 mm.

Diaptomus tatricus Wierzejski.

PLATE X, FIG. 8.

Wierzejski '82 (lacinulatus), and '83; De Guerne and Richard '89.

A large, stout form, with antennæ scarcely exceeding the thorax nd the last segment of the latter produced into a large spindle-shaped, protuberance. The antepenult joint of the male antenna with a hyaline lamina. Inner ramus of fifth feet of the female short, obscurely two jointed; those of the male curved. A tooth is found on the middle of the inner aspect of the basal segment of the left foot, and the apical segment of the outer ramus is forcipate. Length 2.1 mm. Color carmine red.

Diaptomus cœruleus Fischer.

PLATE IX, FIG. 7.

S. Fischer '53 (Cyclopsina cœrulea); Lubbock '63; Poggenpol '74; Uljanin '74; De Guerne and Richard '89.

This widely distributed species has been very frequently confounded with *D. castor*, than which it is rather smaller and from which it differs in possessing a lamina on the antepenultimate segment of the male antenna. The antennæ reach the caudal stylets. The apical segment of the outer ramus of the fifth foot of the female is well developed and its inner spine is almost as long as the claw of the penultimate joint. The inner ramus is two-jointed and longer than the basal joint of the outer ramus. The inner rami of the male feet are one-jointed. Length 1.8 mm.

Diaptomus gracilis Sars.

PLATE IX, FIG. 1.

Sars '64; Gruber '78; Rehberg '80[1]; Daday '85[5]; De Guerne and Richard '89.

This very widely distributed species is scarcely over 1.0 mm. long and very slender. The antennæ are much longer than the whole body. The stylets are short, and the first segments of the abdomen are armed with strong spines. The inner rami of the fifth feet are one-jointed in both sexes, in the female shorter than the basal segment of the outer ramus. The apical joint of the outer ramus is well-developed and bears two spines, one of which is as long as the claw. The inner ramus of the right foot of the male is very long, reaching nearly to the base of the claw. There is a curious, conical, ciliated process from the inner aspect of the outer ramus of the left foot.

Diaptomus orientalis Brady.

PLATE X, FIG. 5.

Brady '86; De Guerne and Richard '89.

There seems to be some doubt whether the various collections from Ceylon and Australia really pertain to the same species.

The last thoracic segment is rounded and armed with short spines, as is the first abdominal. The second abdominal segment is very short. The caudal stylets are short, with long setæ. The antennæ reach the stylets. The antepenultimate segment of the male antenna bears a long hook. The terminal segment of the outer rami is distinct (not so figured by Sars), the inner ramus as long as the basal segment of the outer. Inner rami of male fifth feet very short and one-jointed. Length 1.3 mm.

* **Diaptomus stagnalis** Forbes.

PLATES III; XIII, FIGS. 11, 13.

Forbes '82; Herrick '82 (D. giganteus), and '84; De Guerne and Richard '89.

This species was described by Professor Forbes and the writer at almost the same time, but as the former's description appeared in a periodical it was more promptly distributed and deserves priority.

A very large species, resembling *D. castor*, the place of which it takes in America. Greatest width in front of the middle. The antennæ scarcely extend beyond the thorax. The first segment of the thorax is separated by a suture, as is the last, which is greatly produced laterally and bears two spines. The first abdominal segment is much longer than the rest of the abdomen. The caudal stylets are very short and broad, divaricate, and ciliated externally. The caudal setæ are large, short and profusely plumose. The egg sac is large and spherical. In the male the abdomen is slender and five-jointed. The five joints preceding the hinge of the right male antenna are very

much thickened. The antepenultimate joint bears a small hook and the last two joints are relatively very small. The antennules are of the usual form, the two-jointed branch being much the shorter. The first feet of both sexes have, as usual, the inner ramus two-jointed. The external spines of the outer ramus are longer in the male. The fifth feet of the female have the inner ramus very long and two jointed, armed apically with two very long, setose, equal spines. The apical segment of the outer ramus is distinct and armed with two subequal spines, and is protected by a spine from the preceding joint near its base. The claw is strongly toothed and straight. The right foot of the male is much longer than the left and has a short toothed apical claw. The accessory spine is near the base of the claw. The inner ramus is very small and spatulate. The preceding segment bears a small spine externally and a lamellate appendage within. The inner ramus of the left foot is larger and nearly as long as the basal joint of the outer ramus; it is corrugate internally and bears a short spine apically. Opposite this ramus on the basal segment of the outer are small setæ. The apical segment of the outer ramus bears two curved spines and numerous setæ apically and a hairy plate internally. Length 3.0 to 4.0 mm.

This species has been found in Minnesota, Illinois, Ohio, Kentucky and Alabama.

* **Diaptomus albuquerquensis** Sp. n.

PLATES VI, FIGS. 1-3; VII.

Magnitudine mediocri, Cephalothorax latitudine maxima ad medium sita; segmento ultimo feminæ ad latera extante, utrinque mucronibus 2 armati. Segmentum abdominale 1-mum partem reliquam abdominis, setis exceptis, longitudine superans, utrinque mucrone distincto præditum; segmentum 2-dum per breve. Rami furcales segmento antecedente fere æquantes, intus ciliati. Antennæ 1-mi paris extremam furcam attingentes, vel superantes, 25-articulatæ. Articulus antepenultimus antennæ prehensilis maris processu recto vel subanguiformi sat longo præditus. Pes 5-ti paris feminæ ramo exteriore triarticulato, articulo 3-tio perspicuo, et aculeo interiore circiter ad medium processus unguiformis articulo 2-di porrecto. Processus unguiformis modicis arcuatus, dentibus ad partem medium armatus. Ramus ejus interior extra medium sed non ad finem articuli 1-mi rami exteriores porrectus, biarticulatus, et ad finem ciliatus. Pes dexter 5-ti paris apud marem ramus interior 1-articulatus, per breve, articuli antepenulti rami exterioris longitudinem æquant. Unguis (vel segmentum 3-dum) per magnum, in longitudine pars reliquis pedis superans. Processus lateralis segmenti 2-di magnus, ad basin intus dentibus minutibus affectus. Pedis sinisteri 5-ti paris apud marem, articulus ultimus rami exterioris conicus, intus lamina ciliatus instructus, ad apicem mucronibus duobus affectus. Segmentum 2-dum ejus ramus, intus granulosus. Ramus interior previs, uni articulatus. Animal pleurumque pellucidum, colore albido. Longitud. feminæ 1.4-1.6 mm.

This medium sized species occurs in the water reservoir supplying Albuquerque, New Mexico, together with *D. novamexicanus* in large numbers. The last segment of the thorax is protuberant and bears

two strong spines. The first segment of the abdomen is much longer than the entire remainder of the abdomen and bears a strong spine on either side anteriorly. The stylets are short and ciliated internally. The antennæ reach to the end of the stylets. In the male the antepenultimate segment bears a straight process directed distad and but slightly curved at the tip and shorter than the penultimate segment. The thickened portion of the geniculate antenna is very much modified. The fifth foot of the female has an obscurely two-jointed inner ramus much shorter than the first joint of the outer ramus. The hook of the penultimate segment of the outer ramus is armed with a short series of sharp spines along the middle third of the inner aspect or rather nearer the base than the apex. There is a small spine at the base of the terminal segment, which is distinct and carries two long but unequal spines. The final joint or claw of the outer branch of right fifth foot of the male is very strong and gently curved, being longer than the whole leg. The accessory spine is also heavy and nearer the end than the base of the second segment, and is minutely denticulate near its base. The inner ramus of the right foot is one-jointed, very short, and slightly ciliate at the tip. The left leg reaches to the tip of the inner ramus of the right leg. Its terminal segment is of moderate size and ends in one immovable toothed spine and a bristle; along its inner aspect a ciliated lamina is situated. The preceding segment has a granular area along its inner aspect. The inner ramus resembles that of the right leg.

* **Diaptomus lintoni** Forbes.

PLATE V, FIG. 12.

Forbes '89.

"A large red species occurring commonly with *D. shoshone*, but distinguishable from it at a glance by its different shape, its longer antennæ, its smaller size, and by characters derived from the right antenna and fifth foot of the male. The thorax is symmetrically elliptical in outline, broadest at the middle. The posterior angles are not produced nor bifid, but are each armed with a minute spine. The first segment of the abdomen of the female is not especially produced, but bears at its broadest part a minute spine on each side. The abdomen itself is very short, its length contained about three and one-third times in that of the cephalothorax. The antenna of the female is long and slender, 25-jointed, reaching a little beyond the tip of the abdomen. The fifth pair of legs in this sex is similar to those of *D. shoshone*, but much smaller. The inner ramus is not jointed. It is longer than the basal joint of the outer ramus, bears two stout plumose setæ at the tip, somewhat shorter than the ramus itself, and has also at its inner tip a patch of small spines or fine hairs. The second segment

of the outer ramus with its terminal claw is two thirds as long again as the preceding segment, the breadth of the latter two-thirds its length. The third joint is indicated by a single long, stout seta and one or two smaller ones.

"In the male the geniculate antenna is relatively rather slender, its last two joints without special appendages, its penultimate with a slender transparent apical process, reaching about to the middle of the succeeding segment, acute at tip, but neither serrate nor emarginate. Fifth pair of legs in the male usually without internal ramus to the right leg, but this ramus sometimes represented by a small rudiment. The limb is usually slender and its terminal claw short. The basal segment of the outer ramus is nearly as long as the adjacent segment of the pedicel, and the slender second segment of this ramus is fully as long. Long lateral spines borne near the tip of this segment. The terminal claw is about two-thirds as long as the segment, is somewhat abruptly angulated near its base and slightly recurved at the tip. The inner ramus of the left leg is very stout and long, reaching almost to the tip of the outer ramus, is slightly curved outwards, and has the apex minutely hairy. The basal segment of the outer ramus is thick, two thirds as broad as long, somewhat inflated within, where it extends downwards beyond the articulation with the second segment as a rounded expansion covered with extremely fine hairs. Second segment of this ramus longer than first, but only half as wide, bearing at its tip, within, a rather small, obliquely projecting cushion covered with cilia, and two stout terminal spines, one short, blunt, straight, and smooth, the other curved and plumose, its length about half of the segment to which it is attached." Length 2.5 mm.

* **Diaptomus siciloides** Lilljeborg.

PLATE VIII. FIG. 10.

De Guerne and Richard '89.

This species approaches *D. sicilis* Forbes and *D. caroli* Herrick very closely, and is said also to resemble *D. gracilis* Sars. From *caroli* it may be at once distinguished by reason of the fact that the third joint of the outer ramus of the fifth foot of the female is obsolescent. From the smaller form of *D. sicilis* it is scarcely possible to distinguish it. The spinous armature of the thorax and abdomen seems more marked, and the second segment of the abdomen is shorter in *siciloides* and there is an appendage to the inner aspect of the basal joint of the outer ramus of the right leg. Last two segments of thorax confluent, bearing two lateral spines. First abdominal segment longer than the rest of the abdomen, laterally spined. Second segment very short. Caudal stylets once and a half as long as broad. Antennæ somewhat exceeding the stylets. The antepenult joint of the right

male antenna bears a hook of moderate size. Fifth feet of female short, with a short stout claw and with the inner ramus as long as the basal joint of the outer, one-jointed. The apical joint of the outer ramus is obsolescent, bearing small spines. The male feet are almost exactly as in the small form of *D. sicilis*, but have a process on the basal segment of the outer ramus of the right leg. Length 1.3 mm. Lake Tulan, Fresno, Cal.

* Diaptomus novamexicanus Sp. n.

PLATE VI, FIGS. 7-10.

Inter minores sui generis, modice robustus. Cephalothorax latitudine maxima ante medium sita. Segmentum cephalothoracis ultimum lateribus utrinque mucronibus brevibus ornatum. Segmentum abdominale 1-mum utrinque mucrone brevi instructum. Segmentum 2-di per breve. Rami furcales segmentum antecedens longitudine æquantes, setis apicalibus brevibus. Antennæ 1-mi paris feminæ retro circiter ad furcam vel interdum ad finem furcæ porrectæ, articulis 25 compositæ. Articulus antepenultimus antennæ dextræ maris lamina, antice in processu unguifore, apicem articuli penultimi vix attingente, productus, armatus. Ramus exterior 5-ti paris apud feminam 3-articulatus, processu unguiformi articuli secundi arcuato, intus ad finem denticulato; articulus ultimus distinctus, aculeis 2 brevibus ornatus. Ramus interior 1-articulatus, articulus 1-mus rami exterioris vix longitudine fere æquante. Pedis dextri 5-ti paris apud marem ramus interior uni-articulatus apicem articuli 2-di rami exterioris attingens, apice acutus, pilis obsitus. Unguis terminalis rami exterioris simpliciter arcuatus. Seta accessoria brevis. Pes sinister articulo 2-do rami exterioris oblongovato, versus apicem intus subtilissime aculeato et duos aculeos majores portante, ad basin in lamina ciliata extante. Ramus interior simplex, versus apicem ciliatus, vero longus et ultra medium articuli 2-di rami exterioris porrectus. Animal pleurumque pellucidum, interdum cæruleo vel rubro ornato. Long. feminæ 1.1-1.2 mm.

A small species of rather robust form found associated with *D. albuquerquensis* in the tank of the city water works of Albuquerque, New Mexico. The greatest width is somewhat in advance of the middle. The last cephalothoracic segment is ornamented with small spines only. The first abdominal segment bears on either side a sharp spine. The second segment is quite short. Stylets of moderate length with short setæ. Antennæ reach the stylets. Antepenult segment with a lamina along its distal aspect terminating in a slightly curved process shorter than the penultimate segment. The segment following the geniculation has a hyaline lamina. The fifth foot of the female has a single-jointed inner ramus of considerable length armed at the apex with two spines and small cilia. The claw of the outer ramus is moderately curved and armed near the tip with a series of teeth, the terminal joint is distinct and bears two small spines. The inner rami of the male feet of the fifth pair are simple and rather long. The terminal claw of the right leg is slightly curved and of moderate length, while the accessory spine is nearer the apex of its

segment than the base and is weak and short. The outer ramus of the left foot has a cushion of small spines and two small teeth at the apex and a ciliate lamina along its inner aspect. The inner ramus of this leg is nearly as long as the outer.

*** Diaptomus sanguineus** Forbes.

PLATES V, FIGS. 8, 9; XIII, FIG. 12.

Forbes '76; Herrick '83 and '84; De Guerne and Richard '89; Marsh '93.

A compact species, usually brilliantly colored. Greatest width in front of but near the middle of the cephalothorax. Last segment of thorax laterally produced and armed with two strong spines and produced or "humped" dorsally. First segment of abdomen long, armed with strong lateral spines. Second segment very short. Caudal stylets rather longer than broad, ciliated, setæ short. The antennæ reflexed nearly reach the stylets. The right male antenna is strongly geniculate and its antepenultimate segment is armed with a hyaline lamella forming a short hook apically. The right foot of the male is remarkable for the thick segment bearing the two rami, the outer of which is rather long. The terminal claw is rather short and not strongly curved, and seems at times to be crenulately toothed near the apex. The accessory spine is a little beyond the middle of the second segment of the outer ramus, of which the proximal segment is very small. The inner ramus is short and unarmed (it is incorrectly represented by Forbes as being on the outer aspect), and on the outer aspect is a long spine larger than the ramus, but not jointed, beneath which is an accessory spine or bristle. The left foot is very short and compact —"fleshy" is a suggestive word. The inner ramus is short and unarmed, while a strong spine occupies the corresponding position externally. The apical segment bears a stout claw externally and a smaller opposable spine internally. The species is quite variable. Individuals from very stagnant water may reach 2.0 mm, while others in clear pools do not exceed 1.7 mm. The mean may be taken as 1.8 mm. The curious fact that there is a succession in rain pools in spring beginning with *D. stagnalis* and passing through several varieties to *D. sanguineus* later in the season, has led the writer to suspect an actual transition. Of the heterogenetic character of these forms there is absolute proof as in *Cyclops*, but much farther study is necessary to clear up the most interesting biological laws involved in the distribution of these species.

*** Diaptomus minnetonka** Herrick.

PLATE XIII, FIGS. 8-10.

Herrick '84; De Guerne and Richard '89; Marsh '92.

We are inclined to agree with Marsh that this form is but one of the many variations of *D. sanguineus*. Besides being somewhat smaller than *D. sanguineus* the species differs from it in minor details of the

feet. The inner ramus of the right fifth foot of the male is slender and longer than in *sanguineus;* this is also true of the inner ramus of the left foot. The terminal segment of the outer ramus is provided with the same armature as *sanguineus* and also bears a ciliated plate along its inner aspect. The terminal claw of the right leg is toothed. In the female the inner ramus is more or less distinctly two-jointed and the claw of the outer ramus is toothed. Length of male 1.4 mm. Color dark. In the long antennæ the species differs from *sanguineus*, which it resembles in the armature of the last thoracic and first abdominal segment.

* **Diaptomus armatus** Herrick.

Herrick '82 and 84; De Guerne and Richard '89.

The form, which was indicated by only a few points, in the hope that it might be subsequently rerecognized, has never again been seen. It appears to be allied to *sanguineus*. The antennæ are said to be shorter than the body, the caudal stylets narrow, the right male antenna has a hook upon its antepenultimate joint and is strongly geniculate. But the one feature which may determine the species is the existence of a tooth or spur near the base of the claw of the right fifth foot of the male.

* **Diaptomus oregonensis** Lilljeborg.

PLATES IV, FIGS. 7-12; IX, FIG. 3.

De Guerne and Richard '89; Marsh '93.

This species has been found only in Lake Minnetonka within the limits of Minnesota, though Marsh speaks of it as occurring in Wisconsin very generally in the smaller lakes. It was first found near Portland, Oregon, by Trybom.

The species is of medium size (1.5 mm. long) and rather graceful habit. The antennæ extend beyond the caudal stylets and are strongly spined. The last two thoracic segments are confluent, and bear one or two small spines laterally. The first segment of the abdomen is as long as the remainder and mucronate. The caudal stylets are nearly twice as long as wide. The right male antenna is moderately modified, its antepenultimate segment being unarmed. The apical segment of the outer ramus of the fifth pair of feet in the female is obsolescent with two sharp spines. The claw of the penultimate segment is short and slightly curved; the inner rami are one-jointed and armed with two large spines and fine bristles apically. The fifth feet of the male are sub-equal, the terminal claw of the right foot being geniculately curved and rather long. The accessory spine is near the end of the preceding segment which also bears a small spine near the middle. The inner ramus of the right foot reaches to the spine just

mentioned and bears two teeth. The terminal segment of the left foot is expanded and carries two movable spines and a spur; according to Richard's drawing the spines are dentate and there are accessory ciliar pads along the inner aspect of the outer ramus. The inner ramus is longer than the basal segment of the outer ramus and is ciliated apically.

* **Diaptomus pallidus** Herrick.

Plates IV, Figs. 1-6; V, Fig. 10; XIII, Fig. 17.

Herrick '83 and '84; De Guerne and Richard '89; Marsh '93; Turner '92.

De Guerne and Richard in their monograph quite overlook the original figures and description, for the remarks in *Microscopic Entomostraca* cannot be regarded as a scientific description. It is not to be wondered at that it is considered insufficiently described. This was to be expected from these authors, but is more remarkable from Marsh, who had the paper of 1883 before him but fails to note the figures and description, which, though poor (being prepared on a railroad journey), are diagnostic in respect to the armature of the fifth feet. The credit of completing the description belongs to Marsh.

A slender species of medium size. Cephalothorax widest near the middle; head partially separated by a suture; last cephalothoracic segment fused with its predecessor, armed with one or two minute spines on either side. First abdominal segment long as remainder; second segment shorter than the third. Stylets twice as long as wide. The antennæ are longer than the setæ or at least reach beyond the end of the stylets. Right male antenna without special armature. The terminal segment of the outer rami of the fifth foot of the female is obsolescent and bears two unequal spines. The claw is short and moderately curved. The inner ramus is as long as the basal joint of the outer ramus and bears two long curved spines and a few cilia. The fifth feet of the male are nearly equal, neglecting the claw of the right which is of moderate length and geniculately curved. The accessory spine is short and near the apex, while a small tooth is situated about at the proximal one third of the inner aspect. The inner ramus of the right foot reaches about to this tooth. The armature of the outer ramus of the left foot is peculiar and was not correctly figured by myself or Marsh. Fig. 2 of the plate is a camera drawing of the usual appearance. Fig. 6 is drawn so as to interpret the appearance. There is a movable claw, blunt at the tip and bearing a knob on the inner aspect which fits into the concavity of a basin-shaped projection whose outline is mistaken for a curved claw in most lights. Fig. 6 was taken from a specimen found in Lake Minnetonka. In general, the species prefers clear water. Fig. 1 represents a subimago form, with the first set of

eggs, and is less slender than the adult. The fact that all these species are heterogenentic has been frequently reported by the writer. Length 1.2 to 1.3 mm. Antenna 1.3 to 1.5 mm. Marsh found the species but once, near Marquette.

* Diaptomus piscinæ Forbes.

PLATE V, FIG. 13.

Forbes '93.

A species of medium size (1.75 mm. long), having the last thoracic segment not produced but armed with spines. The fifth feet of the female has the apical segment of the outer ramus obsolescent and the long one-jointed inner ramus provided with spines half as long as the ramus. The male feet are very like those of *D. leptopus*. The outer ramus of the left foot has a quadrate basal joint much wider than the second segment, which bears a small blunt spine and a long curved seta. The inner ramus is nearly as long as both the segments of the outer, and terminates in a broadly rounded, or subtruncate, thickly ciliate end. The terminal claw of the outer ramus of the right leg is short, ciliated; the accessory spine being near its base. The inner ramus is longer than the basal joint of the outer, terminating in a blunt ciliated end.

Diaptomus laciniatus Lilljeborg.

PLATES VIII, FIG. 15; X, FIG. 12.

De Guerne and Richard '89.

This alpine and northern form may be at once recognized among its congeners by the fact that the two last thoracic segments are produced on either side into large projections, of which those of the last one are enormous and are armed with two minute spines. The first abdominal segment is as long as the rest of the abdomen. Caudal stylets short. The antennæ extend beyond the stylets. Length without stylets 1.8 mm. to 1.2 mm.

Diaptomus castor (Jurine.)

PLATE IX, FIG. 5.

Jurine '20 (Monoculus castor); Koch '35 (Glaucea rubens); Lilljeborg '53; Lubbock '63; De Guerne and Richard '89.

The confusion of several species under this name and loose descriptions of European authors stood in the way of any differentiation of non-European species until very recently. In fact, until the appearance of De Guerne and Richard's work no writer could feel safe in the attempt to distinguish species in this genus. All references to *D. castor* in America are erroneous. In our own case *D. leptopus* has been most often so called.

A large robust species (2.5 to 3.0 mm. long), with the last abdominal segment produced into two long acuminate and mucronate lobes. The first abdominal segment is also produced and spined. The antennæ are short, barely reaching the second abdominal segment. The third joint of the outer ramus of the fifth foot is large and furnished with two unequal spines, one being very long. The claw is short and serrate. The inner ramus is two-jointed and armed with one very long and one short spine. The inner ramus of the right foot is two-jointed, and of the left, one-jointed in the male.

Two varieties or subspecies are recognized as separate species, but seem to be due to difference of station simply.

Diaptomus glacialis Lilljeborg.

PLATE IX, FIG. 8.

De Guerne and Richard '89.

The last two thoracic lobes are confluent dorsally and are produced into even longer lateral processes than *D. castor*. Processes of the rostrum differ from those of *D. castor* in being elongate, sinuate, and obtuse. The fifth feet of the male differ chiefly in that the inner ramus of the right leg is very indistinctly two-jointed. There is occasionally a rudimentary appendage upon the antepenult segment of the male antenna. 3.0 mm. long. Glacial waters of Nova Zembla, etc.

Diaptomus mirus Lilljeborg.

PLATE VIII, FIG. 8.

De Guerne and Richard '89.

A species or variety even larger than *D. castor* (3.6 mm. long) and differing very little from *D. glacialis*. The lateral projections from the last thoracic segment (which is distinct) are smaller, and the first abdominal segment is not produced into great lateral processes. The fifth feet are almost identical in the two species. The fifth feet of the males differ only in the proportional development of the parts. The form was found in Siberia by the Nordenskiöld expedition.

Diaptomus sancti-patricii Brady.

PLATE XXXIII, FIGS. 9-11.

Brady '91.

Posterior angles of the last thoracic segment very much produced so as to form attenuated spines. Anterior antennæ reaching about as far as apex of furca; penultimate joint of the anterior antenna of the male entirely destitute of marginal process. Inner branch of the fifth pair of feet in the female indistinctly biarticulate, nearly as long as

the first joint of the outer branch, and bearing three minute apical setæ. Last joint of the outer branch small, the larger apical seta not reaching as far as the extremity of the claw of the penultimate joint. Inner branch of the right foot in the male simple, mucronate at the apex, and reaching beyond the middle of the last joint of the outer branch; terminal claw of the outer branch strongly falcate, and delicately ciliated on the inner edge; lateral spine attached near the middle of the last joint, long, slender, and finely ciliated. Fifth foot of the left side (male) terminating in a subcrescenti form hyaline lamina, the inner edge of which is delicately crenulated. Length of male and female about 1.55 mm.

Diaptomus lilljeborgi De Guerne and Richard.

PLATE IX, FIG. 6.

De Guerne and Richard '88[1] and '89.

This rather large species (2.0 mm. long) is sufficiently identified by the greatly expanded inner ramus of the right foot. The last thoracic segment is alate and mucronate; the first abdominal being also spined. The antennæ are scarcely longer than the thorax, and that of the male as in *D. castor*. Algiers.

Diaptomus roubaui Richard.

PLATES VIII, FIG. 2; IX, FIG. 11.

Richard '88; De Guerne and Richard '89.

This, which is perhaps the largest species of the genus (5.0 to 6.0 mm.) is recognized by the expansion of the right side of the first abdominal segment to form a rounded spinous protuberance while the third and fourth segments of the male are produced and opposable. The antennæ scarcely exceed the thorax. The female fifth feet are like those of *D. castor*. The inner rami of the male feet are one-jointed; that of the right foot being curved and thickened at the apex, that of the left foot indistinctly two-jointed and as long as the basal segment of the outer ramus, which is narrow and armed with spines internally. The terminal joint of the outer ramus is swollen and pilose and armed with two thick spines.

* **Diaptomus tyrrelli** Poppe.

PLATE X, FIG. 9.

Poppe '88.

A species from Summit lake (altitude 5,300 feet, in the Rocky mountains) and Centreville, Cal., of moderate size (1.9 mm.) and greatly expanded and spined thoracic angles. The first abdominal segment is as long as the remainder and expanded and spined ante-

riorly. The second segment is transversely wrinkled. Antennæ extend to the stylets. Right male antenna with an unarmed antepenult joint. Third joint of outer ramus of fifth feet obsolescent, inner ramus slender and as long as the basal joint of the outer ramus. The outer ramus of the right male foot with a small hyaline process; accessory spine near the middle of the second joint small. The inner ramus is short and acuminate. Inner ramus of left foot long, two-jointed, hirsute apically. Outer ramus short.

Diaptomus theeli Lilljeborg.

PLATE VIII, FIG. 11.

De Guerne and Richard '89.

A species very much like *D. laciniatus*, except that the last two thoracic segments are not both produced into long projections, as in that species, the last being moderately produced and mucronate. The first abdominal segment is very long (as in the last), and somewhat expanded anteriorly. The fifth feet of the female have the terminal segment of the outer ramus distinct and the inner ramus generally (in old forms) two-jointed. There is a small hyaline lobe from the inner aspect of the peduncle of the right leg in the male. The inner ramus of this leg is curved and acuminate. The inner ramus of the left leg is shorter than the basal joint of the outer ramus and acute, with a small spine near the apex. 2.0 mm. long. Collected by the Nordenskiold expedition in Sibera.

Diaptomus lobatus Lilljeborg.

PLATE VIII, FIG. 7.

De Guerne and Richard '89.

A species occurring with the last, from which we are unable to find any sufficient reason for separating it. The last two thoracic segments are partly fused, and the last segment projects somewhat more than in *D. theeli*, and there are minor differences in the feet but of very doubtful value. Size the same. Such differences as exist may be gathered from the figures.

Diaptomus affinis Uljanin.

PLATE X, FIG. 10.

Uljanin '75; De Guerne and Richard '89.

A small form from Turkestan approaching *D. denticornis*, but lacking the armature of the male antenna. The first abdominal segment is unarmed, while the last thoracic has merely two small spines. Antennæ reach the end of the last abdominal segment. The last joint of the

outer ramus of the fifth feet of the female obsolescent, inner ramus one-jointed, longer than the basal joint of the outer ramus. The figures of the male feet are imperfect, but indicate small one-jointed internal rami on both sides. 1.6 to 1.4 mm. long.

Diaptomus amblyodon Marenzeller.

PLATE IX, FIG. 2.

Marenzeller '73; Kortchaguine '73 and '87 (D. bogdanowi); De Guerne and Richard '89.

A large species very nearly allied to *D. gracilis* (4.0 to 4.5 mm. long). Last segment of the thorax ornamented with two spines. First abdominal segment with a conical process on either side armed with a long spine. Antennæ extending to the end of the thorax. Last segment of the outer ramus of the fifth foot of the female well developed, inner ramus one-jointed, equaling the basal joint of the outer ramus and bearing three setæ; the claw strongly toothed. Inner rami of the male fifth foot one-jointed, short, unarmed. The basal joint of the outer ramus of the right leg with a small lobe. Apical segment of the left leg densely spiny, with two larger spines.

We receive too late to enter the above list in the appropriate places descriptions of two species of *Diaptomus* by Professor Marsh ('94). The descriptions are given verbatim with a reduced reproduction of the figures.

* **Diaptomus mississippiensis** Marsh.

PLATE XLVII, FIGS. 1-3.

"Of moderate size. The first two segments of the cephalothorax are nearly equal in length, and together form somewhat less than half the cephalothorax. The last segment of the cephalothorax is armed behind with two minute spines.

"The first segment of the abdomen of the female is as long as the remainder of the abdomen and the furca; it is dilated laterally and in front, and bears two prominent lateral spines, the right spine being considerably larger than the left. The second segment is somewhat shorter than the third, and the third and the furca are of about equal length.

"The antennæ reach beyond the furca. The right antenna of the male is swollen anterior to the geniculating joint, and the antepenultimate joint is without armature.

"The outer ramus of the fifth foot of the female is two-jointed, the third joint being represented by two spines. The inner ramus is one-jointed, a little longer than the first joint of the outer ramus, and armed at the tip with minute setæ and two rather long spines.

"In the right fifth foot of the male the basal joint is dilated on the inner margin. The first joint of the outer ramus is slightly broader than long. The second joint is elongated, quadrangular, with the

lateral spine situated at the distal end. The terminal hook has the symmetry of the curve broken by two rather abrupt angles, and its inner margin is armed with fine serrulations. The inner ramus is one-jointed, and reaches about half the length of the second joint of the outer ramus.

"The left fifth foot of the male reaches to about the middle of the second joint of the outer ramus of the right. The first joint of the outer ramus is as broad as long. The second joint is armed at tip with two finger-like processes, and both joints are armed within with minute hairs. The inner ramus is one jointed, and nearly equal in length to the outer ramus. Length of female, 1.2 mm.; male, 1.1 mm.

"This species was found in some material kindly furnished to me by Professor E. A. Birge. The collections were made in January and February, 1893, in small lakes and ponds in Mississippi. It was the only *Diaptomus* in the collections, and was found in nearly all of them. It will be noticed that it bears a somewhat close resemblance to *D. graciloides* Sars."

* Diaptomus birgei Marsh.

PLATE XLVII, FIGS. 4-6.

"Of moderate size. The first segment of the cephalothorax is nearly equal in length to the three following.

"The first segment of the abdomen of the female is as long as the remainder of the abdomen and the furca. It is much dilated in front. The second segment is nearly twice as long as the third, and about equal in length to the furca. The second and third joints are very closely united.

"The antennæ extend to the end of the furca. The right antenna of the male is much swollen anterior to the geniculating joint; the antepenultimate joint is produced on its distal end into a short, blunt process, which makes very nearly a right angle with the longitudinal axis of the joint.

"The outer ramus of the fifth foot of the female is two-jointed, the third joint being represented by two spines. The inner ramus is one-jointed, hardly as long as the first joint of the outer ramus, and armed at the tip with minute setæ and two rather long spines.

"The basal joint of the right fifth foot of the male is elongated, trapezoidal in form, it greatest breadth being at its distal extremity. The first joint of the outer ramus is broader than long, armed on its inner margin with a broad, thin expansion of the integument. The second joint is elongate, broader at base; the lateral spine is situated at about the middle of its length, is long and stout, and armed on its inner margin with fine serrulations. The terminal hook is slightly

angular and armed with fine serrulations on its inner margin. The inner ramus is one-jointed, equaling in length the first joint of the outer ramus.

"The left fifth foot of the male reaches slightly beyond the first joint of the outer ramus of the right. The basal joint is quadrangular, considerably shorter than the right basal joint. The first joint of the outer ramus is about twice as long as broad. The second joint is slightly longer than the first joint; it is expanded at base, where it is armed with fine hairs, and terminates in a finger-like process bearing a falciform spine. The inner ramus extends to about one-half the length of the second joint. Length of female, 1.5 mm.; male, 1.3 mm.

"The material in which this species was found was collected by Professor E. A. Birge at New Lisbon, Wisconsin, and only a few individuals were found. I have expected to find it in the collections from other Wisconsin localities; but so far my search has been without success. It is a clearly marked species resembling the European *D. gracilis* Sars more closely than does any other described American species. The characters of the fifth feet, however, separate it from the European form.

"I have taken the liberty of naming this species in honor of Professor Birge, to whose kind assistance and encouragement I have been greatly indebted."

GENUS BROTEAS Loven. 1845.

Thorax five-jointed. First antennæ multiarticulate; second pair bi-ramose. Swimming feet four pairs, bi-ramose, outer ramus three-jointed, inner two jointed; fifth feet dissimilar in the sexes. The third pair of maxillipeds falciform. Abdomen of the male six-jointed, in the female two-jointed. The single known species, *B. falcifer* Loven (Plate X, Fig. 16), a large slender form (4.0 mm. long), occurs in salt pans near Port Natal.

GENUS HETEROCOPE Sars. 1863.

Cephalothorax six-jointed; last thoracic segment more or less divaricate alike in the two sexes. Abdomen of female three-jointed, of the male five-jointed. Caudal stylets; larger setæ three. Antennæ 25-jointed; in the male right antenna a geniculating joint between segments 18 and 19, the six preceding somewhat tumid. Swimming feet four pairs, of which the outer rami three-jointed, the inner one-jointed. Fifth feet of female simple, three-jointed, those of the male dissimilar; the left cheliform. Abdomen of the male symmetrical.

Heterocope is obviously the eastern homologue of *Epischura*.

The three species of this genus may be tabulated thus, following De Guerne and Richard:

I. Antennæ shorter than the body. Stylets armed at the angle with a short non-ciliated seta. The female has no appendages at the genital orifice. The last segment of fifth foot on the right side of male short. . . . . **saliens** and **borealis**

II. Antennæ longer than the body. Stylets without the setæ at the angle. Female with eight appendages at the genital orifice. Last joint of the male right fifth foot long and straight. . . **appendiculata**

Heterocope saliens Lilljeborg. 1862.

PLATE X, FIG. 14.

Last segment of the fifth feet of the female short and broad, teeth of its internal aspect distinctly bifid. The prolongation of the inner aspect of the antepenult joint of the left fifth foot of the male incurved, not reflexed at its end.

Heterocope borealis Fischer. 1851

PLATE X, FIG. 15.

Last segment of the fifth foot of female long and straight, teeth less distinctly bifid or trifid. Prolongation of male left foot much curved and reflexed at the end.

Heterocope appendiculata Sars. 1863.

PLATE XI, FIG. 3.

Two other species, *H. alpina* and *H. romana*, have been described by Imhof ('88). These forms remain imperfectly known and may be simply young of other species.

GENUS EPISCHURA Forbes. 1882.

Related with *Heterocope* Sars. The thorax is six-jointed, the last two segments partly united. The abdomen is five-jointed in the male and four-jointed in the female. Antennæ 25-jointed, the right male being geniculate. Abdomen of male with prehensile appendages, often more or less distorted. Inner rami of swimming feet one-jointed. Fifth feet one-branched, in the male modified for prehension. Caudal stylets with three long setæ. The first mention of an animal of this genus seems to be Pickering's description of *Scopiphora vagans* from deep water in Lake Ontario. It seems almost certain that the species so imperfectly described in Dekay's Crustacea of New York, is none other than a species of *Epischura*, but I hesitate to substitute for a name accompanied by good descriptions and figures, and one which has already been incorporated to some extent into our literature, one which is founded on a description so imperfect and general that one incidental character alone enables one to guess its application. The following is Pickering's description:

"Body small, eye single, near the anterior margin of the shield. Antennæ large, and as long as in the preceding genus (*Cyclops*), and has the same motions in the water. Abdomen terminating in two styles, each with three setæ; last or three last joints. Ovaries none; legs spiny."

What is meant by the "brush" fails to appear, unless the specimens were ornamented with some parasitic plants or animals. The three setæ of the caudal stylets and long antennæ will place this form in no American genus save *Epischura*. But even this statement of Pickering may be held doubtful.

* **Epischura lacustris** Forbes.

PLATE XIII, FIG. 15.

Forbes '82; Herrick '84 and '87; De Guerne and Richard '89.

"The second segment of the abdomen of the male is twice as long as the first, and produced to the right as a large, elongate, triangular process, somewhat hooked backwards at the tip. The third segment is similarly produced, but rounded and expanded at the tip, which is roughened before and behind.

"From the right side of the fourth segment arises a stout process bearing at its apex a hatchet-shaped plate with seven broad obtuse serratures on its anterior margin. This process is roughened behind, where it is opposed to the concave side of the left ramus of the furca. From the same side of the fifth segment, a short flattened plate, of a spatulate or paddle-like form, extends forward above or beyond the toothed process just mentioned.

"The antennæ are 25-jointed, and reach to the second segment of the abdomen. There are especially prominent sensory hairs on the first and third joints, borne at the tips of long spines. The antennules are short, the ramus apparently but three-jointed, the short, median joints common in this appendage being only obscurely indicated. The mandible has but seven teeth, the first simple and acute, separated from the second by an interval about equal to the second and third, the second to the sixth bifid, the seventh entire and acute. The usual plumose bristle is replaced by a sharp, simple spine.

"The outer ramus of the fourth pair of legs has two teeth at the outer tip of each of the two basal joints. The terminal joint of this ramus is armed as follows: a short simple spine at middle of outer margin and another at the distal outer angle; a single and long terminal seta, strongly and sharply toothed externally and plumose within, and four long plumose setæ attached to the inner margin.

"The left leg of the fifth pair in the male, viewed from behind, has the basal joint very large, broader than long, with the inner inferior angle produced downwards as a long, stout, curved process or arm as

long as the two remaining joints. The second joint is trapezoidal, shortest within. The third joint is about half as wide at base as the first, is straight without, with a sharp, small tooth at its distal third, and bifid at tip. On the inner margin this joint is at first dilated a little, and then deeply excavated to the narrow tip, to receive the lower end of the left leg, the lower two-thirds of this margin forming the segment of a circle.

"The right leg is two-jointed, the first joint twice as broad, enlarged at the lower end, forming an auriculate expansion at its inner inferior angle. The second joint is conical in outline and about two-thirds as long as the first.

"The terminal bristles of the rami are very broad and strong in the female, the outer one especially having an extraordinary size and thickness. There is also at the outer angle of each ramus a short, stout spine, that on the left ramus being inflated like the outer bristle. Length .065 in.

"The legs of the fifth pair in the female are three-jointed and similar, the basal joint short and broad, the second two and one-half times as long as wide. The leg terminates by four diverging teeth, preceded by two others, one on each side.

"Taken in the towing net abundantly in October, 1881, at Grand Traverse bay; also obtained rarely by Mr. B. W. Thomas, from the city water of Chicago."

Occurring in Minnesota, probably in Lake Superior.

* **Epischura fluviatilis** Herrick.

PLATE XIII, FIGS. 14, 16.

Herrick '83, '84 and '87; De Guerne and Richard '89.

"Similar to the above but smaller (0.04 in.). The females are very similar, though the fifth feet are more elongate and differently spined. The abdomen is perfectly straight and the three caudal setæ are of nearly equal size. The claw is armed with eight teeth, all but the first of which are emarginate. The abdomen of the male is straight, but has a strong process on the left side which bears a movable claw laterally and a small second segment which terminates in two small spines. The fifth foot of the male is peculiar; the inner ramus (or the left foot) lamelliform, one-jointed, with two opposable claws; the right branch is simple and three-jointed, in form like that of the female. Here we have the most marked difference between the two species. Found in Mulberry creek, Cullman county, Ala. Although a considerable number were examined no oviferous females were found, while the males contained the spermatophores and can hardly be thought immature, and, as it is in the male that the most marked differences appear, the two species seem certainly distinct."

It is to be regretted that no opportunity has occurred to observe this species since the above was written. It is very probable that mature examples would modify as well as extend the above. It is a bit amusing to find De Guerne concerned over the discrepancy of our locating "baie de Mulberry" in a mountain region—a difficulty which would disappear should he grasp the English usage of "creek" which he has translated "baie."

* **Epischura nevadensis** Lilljeborg.

PLATE XI, FIGS. 1, 6, 8.

De Guerne and Richard '89.

Of moderate size. Cephalothorax five-jointed; last two confluent; last segment not devaricate, rounded. Abdomen three jointed in the female. Caudal stylets shorter than the preceding segment; slightly ciliated internally; caudal seta equal and similar; externally a short spine. Abdomen of male five-jointed, curved to the right, similar to that of *E. lacustris*, second and third segments nearly equal in length, the first shorter; the second segment produced on the right side into a very large wing-like process, denticulate along its hinder border and emarginate at the tip: third segment with a shorter, smooth and broadly rounded process. The fifth segment with a process on both sides. Antennæ not reaching the base of the stylets. Antepenult joint of male right antenna not appendaged. Fifth feet of female uniramose, three-jointed, more robust than usual. Apical joint with six teeth, of which four are longer. Fifth feet of male uni-ramose, dissimilar. Right foot apparently two-jointed, the basal joint thick with a lamellate and denticulate process at the end, second joint a thick claw. First joint of the left foot a very large hook; third joint incised internally, the shallow excavation ciliated, and armed apically with two spines. Length of female 2.0 mm.

Found by A. G. Eisen in the Sierra Nevada region, Lake Tahoe and Echo lake.

* **Epischura nevadensis** Lilljeborg. Var. **Columbiæ** Forbes.

PLATE XI, FIGS. 4, 10.

Forbes '93.

This alpine form is not only a little larger but the thorax is more distinctly jointed. The antennæ of the female reach to the posterior end of the penultimate segment of the abdomen. The first segment of the abdomen is as long as the two following together, and the stylets are as long as the preceding segment. The abdomen is not curved as in *E. lacustris*. The three caudal setæ are all similar and of equal width. There is a stout conical spine at the outer distal angle and a soft seta at the inner angle of each stylet.

The fifth legs of the female are broader proportionally than those of *lacustris* but more slender than those of *E. nevadensis*. The last segment is four times as long as broad and bears six (7) teeth, of which four are terminal. The second, third and fifth segments of the male abdomen bear lateral processes extending toward the right. The first three segments are subequal. The lateral process of the second has the form of a stout but thin lamina projecting to a distance equal to the width of the segment; it is acute at the apex, with the point a little recurved, convex and smooth in front, and nearly straight behind, except that this edge is irregularly serrate throughout and deeply emarginate where it joins the segment. This blade is strongly curved ventrad like the following. The third segment bears a broad thin lamina which projects outward, as wide as long, broadly rounded at the end, simple but strengthened beneath by a ridge of chitin. From the fourth segment spring two processes, the ventral being nearly similar to that of *nevadensis*. The dorsal process is a small irregular plate curving forward, inward and downward. Length of female 2.12 to 2.4 mm.

* **Epischura nordenskioldi** Lilljeborg.

PLATE XI, FIGS. 2, 5, 9.

De Guerne and Richard '89.

This species, from St. Johns, Newfoundland, is the largest of the genus (2.9 mm.) and is remarkable for the slender, slightly armed abdomen. Cephalothorax robust, abdomen exceedingly slender, four-jointed in the female, anterior two somewhat fused, third segment longer than the fourth. Caudal stylets twice as long as wide, ciliated internally; caudal setæ similar and equal. Male abdomen five-jointed and slightly flexed toward the right, second and third joints equal and half as long again as the first. The second joint is armed with a rather small, slightly curved, and notched at the tip. The process of the third joint is very small and acute; that from the last is directed cephalad and is blunt. Antennæ reaching to base of stylets, 25-jointed. Geniculate antenna with the penultimate joint unarmed. Feet of fifth pair in the female uni ramose, three-jointed, nearly as slender as in *E. lacustris* though less so than *E. fluviatilis*, the joints nearly of equal length. The left fifth foot of the male closely resembles that of *E. columbiæ;* the right differing from the other forms in having an accessory spine near the base of the inner aspect.

GENUS OSPHRANTICUM Forbes. 1882.

(=Potamoichetor, Herrick.)

First reported as *Potamoichetor* before the Minnesota Academy of Sciences in 1879, but owing to a disastrous fire, publication was prevented. Priority probably belongs to Forbes' name, since, although

first printed in the tenth annual of this survey, the edition was not distributed till after the August issue of the American Naturalist of 1882, containing the description above alluded to. Forbes says this genus has antennæ 23-jointed; all the specimens we have gathered from Minnesota to Alabama had 24-jointed antennæ. The original description of "*Potamoichetor*" is appended.

"Cephalothorax six-jointed, distal segments evident; abdomen, in the male, five-jointed, in the female four-jointed; antennæ 24-jointed, the right geniculated as in *Centropages* (=*Ichthyophorbia*); first pair of feet with the rami both three-jointed, like the following; feet of the fifth pair, in the female, like the preceding, but with a spine of the joint preceding the terminal one enlarged and divaricated somewhat as in *Centropages:* in the male, the right with a two-jointed outer ramus, the terminal joint of which is spined and bears near its base a blunt expansion of its inner margin; outer ramus of left foot three-jointed, armed with unequal spines; inner branches smaller, similar, three-jointed; the terminal joint bearing curved spines; ovary and testes as in *Diaptomus*, with which the mouth parts agree in the main; eyes median, confluent."

Ovisac very large, elongate.

Our own experience is that the single species of this genus prefers estuaries of running water. Forbes, however, has taken it from swamps and wayside pools.

* **Osphranticum labronectum** Forbes.

PLATES XII, FIGS. 1-8, 13, 14; LIX, FIGS. 7, 8.

Forbes '82; Herrick '82 (Potamoichetor fucosus), '84 and '87; De Guerne and Richard '89.

"Rather slender, and in size, as well as general appearance, resembling the smaller forms of *Diaptomus;* antennæ rather stout, reaching but little beyond the feet, appendaged as in *Diaptomus*, in the male strongly geniculated, but somewhat variously so; the six joints preceding the terminal four are thickened; those preceding the joint or hinge are arcuate on the distal margins; the secondary antennæ are about as in *Diaptomus;* mandibular palp two-branched, the outer three-jointed, the inner two jointed; the terminal joint of the shorter branch bearing seven setæ, of the other four, the proximal joint of the former with three stout spines; the maxillæ nearly like *Diaptomus;* the processes have respectively the following numbers of setæ: the basal plate eight, the small processes at base of posterior branchial appendage one, the appendage itself twelve, terminal portion three groups, first containing nine, the second three, and the third four or five, the upper of the anterior processes two, and the lower three; fifth feet nearly like the others in size; the right in the male having the outer

branch but two-jointed by the coalescence of the two outer to form an arcuate and deformed appendage, armed at the end with three stout equal spines; corresponding branch of left foot three-jointed; the terminal joint bearing three unequal spines, each of the preceding joints only one; inner branches similar, three jointed; terminal joint being short and armed with three short lanceolate setæ and three longer ones, two of which are curved so as to be slightly prehensile; fifth foot of female with both rami three jointed; inner ramus much smaller; antepenult segment of the outer ramus extending into a large lanceolate process; ovisac long-ellipsoidal or spherical, reaching nearly to the end of the caudal setæ."

Professor Lilljeborg finds this species in Oregon, and as we have collected it in Alabama it may be regarded as ubiquitous in North America in suitable stations.

FAMILY CYCLOPIDÆ.

The family contains five genera, viz.: *Thorellia*, *Cyclops*, *Oithona*, *Lophophorus* and *Cyclopina;* passing, by the genera *Misophria* and *Pseudo-cyclops*, into the *Calanidæ* or marine *Copepoda*. The affinities of these little known genera need further study, as they are very interesting, the question being still open in how far the cyclopoid forms are altered by adaptation to saline habitat, if such an adaptation takes place at all.

Cephalothorax ovate and usually much more robust than the abdomen; anterior antennæ seldom longer than the cephalothorax, those of male alike on both sides and modified for the purpose of clasping; posterior antennæ unbranched (i. e., palpus wanting); palps of mandibles and maxillæ usually well developed; foot-jaws mostly less developed than in *Calanidæ;* first four pairs of feet as in *Calanidæ*, fifth pair rudimentary, alike in both sexes, and usually one- or two-jointed; ovisacs two.

The circulatory system of this family is partly lacunal and has been thought to be entirely so in the genus *Cyclops*. Closer observation, however, shows that there is something like an imperfect central organ at the point occupied by the heart of higher *Copepoda*. This was figured in my previous report, Plate V, Fig. 1, but no mention was made of the discovery. It has since been verified. The apparatus referred to is a modification of that described under *Canthocamptus*. In the second thoracic segment there is a set of swaying membranes which constitute a valvular apparatus, chiefly moved by the action of the stomach.

The following analytical key from Brady will serve to differentiate the genera.

KEY TO THE FAMILY CYCLOPIDÆ.

I. MANDIBLAR PALP OBSOLESCENT, a mere tubercle bearing two filaments.
  a. Second maxillepeds prehensile. . . . . **Thorellia.**
  b. Second maxillepeds not prehensile. . . . . **Cyclops.**
II. MANDIBLAR PALP TWO-BRANCHED.
  a. Secondary branch of palp many-jointed. . . . . **Oithona.**
  b. Secondary branch one-jointed.
    * Fifth pair of feet foliaceous. . . . . **Lophophorus.**
    ** Fifth pair of feet cylindrical, two- or three-jointed. . . . **Cyclopina.**

All these genera except *Cyclops* are marine.

GENUS CYCLOPS.

The sole representative of the genera of the *Cyclopidæ* here treated is the best known of the *Copepoda*. Every one is familiar with the "common *Cyclops*," but few realize how many are the species included under this name. An attempt is here made to enable the student to recognize the more obvious distinctions upon which the genus is subdivided and to identify such of the species as seem valid and at the same time recognizable without recondite study of development. Without attempting a complete elucidation of the synonymy, which is practically an impossibility, a proximate classification of all the species known to me is attempted.

DIAGNOSIS: Cephalothorax robust, oval, broadest in front, composed, in the female, of nine segments. Antennæ short, of less than twenty segments, in the male geniculate on both sides. Antennules one-branched, four-jointed. Mandiblar palp a small two-setose tubercle. First four pairs of feet two-branched, all the branches three-jointed. Fifth feet small, one- to three-jointed. In the male a still more rudimentary sixth pair. Eye single but composed of two facets. Ovisac double.

As stated by Brady, the genus *Cyclops* is, as regards discrimination of species, one of the most difficult and puzzling of all the *Copepoda*. Chief among the causes of this difficulty is the polymorphism and heterogenesis which prevail, as well as the great susceptibility to the effects of the environment. Living as they do, in pools and streams, undergoing great seasonal and other variation, these forms offer exceptional opportunities for the study of the plasticity of species.

KEY TO THE GENUS CYCLOPS.

I. Antennæ 18-jointed.
II. Antennæ 17-jointed.
  a. Fifth foot one-jointed. . . . . **ater,** 89.
  b. Fifth foot two-jointed.

* First joint of the fifth foot broad. . . **viridis,** 90; **americanus,** 91; **ingens,** 92; **vernalis,** 92; **robustus,** 93; **parcus,** 93; **brevispinosus,** 95; **uniangulatus,** 96; **leuckarti,** 96; **scourfieldi,** 98; **oithonoides,** 98; **dybowskii,** 99; **bisetosus,** 99.

** First joint of the fifth foot longer than wide.

† Terminal segment of the fifth foot with one long seta and one short spine. . . . . **strenuus,** 99; **lacustris,** 101.

†† Terminal segment of the fifth foot with two rather long setæ, **pulchellus,** 101; **minutus,** 103; **forbesi,** 104.

††† Terminal segment of the fifth foot with three setæ. . **signatus** 105; **var. coronatus,** 106; **var. tenuicornis,** 106.

III. Antennæ 16-jointed, **languidus,** 107; **modestus,** 108; **capilliferus,** 109;

IV. Antennæ 14-jointed. . . . . **insignis,** 110.

V. Antennæ 12-jointed.

a. Fifth foot one-jointed. . . . **serrulatus,** 111; **var. elegans,** 112. **macrurus,** 113; **prasinus,** 113; **fluviatilis,** 114.

b. Fifth foot two-jointed. . . . **capillatus,** 115; **crassicaudis,** 115; **varicans,** 116.

VI. Antennæ 11-jointed. . . **gracilis,** 117; **diaphanus,** 117; **affinis,** 117; **bicolor,** 118.

VII. Antennæ 10-jointed. . . . . **phaleratus,** 120.

VIII. Antennæ eight-jointed. . . . . **fimbriatus,** 121.

IX. Antennæ six-jointed. . . . . **æquoreus,** 122.

The forms which have been reported with 18-jointed antennæ may not necessarily be representatives of a single species but may be sporadic instances of reduplication in the antennal segments on the part of various 17-jointed forms. *Cyclops elongatus* Claus, the only named species with 18-jointed antennæ, is confidently identified with *C. vernalis* Fischer, by Schmeil, nevertheless Claus' description is as follows: "Length of body 2.5 mm., elongate, gradually narrowed toward the end. The anterior antennæ 18 jointed, differing from the 17-jointed type by the separation of the seventh joint into two: they do not extend far beyond the first segment of the cephalothorax. The fifth abdominal segment is strongly toothed. Rudimentary foot two-jointed, with relatively small basal joint and elongate terminal one, on whose apex is one long and one short seta. The stylets are longer than the two last abdominal segments, with relatively short setæ, whose relative size is nearly like those of *C. cuspidatus.*"

This species is reported by Cragin from near Cambridge, but has been seen by no other observer except the describer.

***Cyclops ater** Herrick.

PLATES VI, FIGS. 11, 12; XII, FIGS. 9-12; XXI, FIGS. 13-15, 17, 18.

Herrick '82, '84, '87; Turner '92.

Cephalothorax very large and broadly oval and usually conspicuously colored. Antennæ as long as the cephalothorax (1.2 mm.),

slender, tapering toward the end; formula* –⏓⏑––⏑–⏑⏑⏑⏑⏓⏓⏑ –––; last three segments not elongate, the last being furnished with an unserrated, hyaline knife-like ridge as in *C. tenuicornis.* Antennules much as in *C. tenuicornis.* Maxillipedes rather large. Fifth foot one-jointed, armed with three subequal spines. Abdomen very short, especially the last segment. Stylets rather more than twice as long as wide, the three inner setæ long and pectinate but none very long, external seta short, lateral seta near the end of the stylet. Fourth foot with the following armature of apical joints:

Outer ramus	†ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	4 setæ.		in.	2 setæ.

The setæ are all short and stout. Color deep blue or gray; young with a deep band of color crossing the thorax near the middle. Ovisacs pale, rather small. Length 2.1 mm. This, our most characteristic American species, is sparingly but widely distributed, at least, throughout the Mississippi Valley.

Cyclops viridis Jurine. 1820.

PLATE XIV.

Subspecies europæus Herrick.

Var. a.—Koch '35 (C. vulgaris); Fischer '51; Claus '57 and '63 (C. brevicornis); Sars '63; Lubbock '63 (C. brevicornis); Heller '70 (C. brevicornis); Fric '72[1] (C. brevicornis); Uljanin '75; Hoek '76 (C. brevicornis); Rehberg '80[1]; Daday '85[5]; Vosseler '86; Sostaric '88; Thallwitz '90; Lande '90; Schmeil '91; Richard '91; Schmeil '92.

Var. b.—Claus '57 (C. gigas); Sars '63 (C. gigas); Fric '72[1] (C. gigas); Brady '78 (C. gigas); Sostaric (C. viridis var. gigas); Rehberg '80[1].

Subspecies americanus Marsh.

Var. a.—Cragin '83 (C. viridis); Herrick '83 (C. parcus) and '84 (C. brevicornis) (passim); Marsh '93 (C. americanus); Turner '92 (C. viridis).

Var. b.—Herrick '82 and '83 (C. ingens).

If we accept Rehberg's suggestion that the two European species, *C. brevicornis* and *C. gigas*, are but forms of the same species, we are driven to a somewhat anomalous arrangement of the synonomy, though, when so arranged, it expresses a not unusual parallel development of species on the two sides of the Atlantic. As the writer stated in 1882, the American representatives of this species differ in several minor points from the European and a new name was given. Later, in deference to Rehberg's discovery of greater latitude of varia-

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* The characters in these formulæ are used to indicate the relative length of the joints, from base to tip, as follows: ⏑, short; ⏓, medium; –, long.

†ex. exterior; ap.=apical; in.=interior aspect.

tion than once supposed, *C. ingens* was united with *C. gigas* as an unnamed variety of *C. viridis* (Herrick '84, p. 145). The preimago stage is similar to that of *gigas*, and this fact made the union seem more legitimate. Still later Marsh, without recognizing the varietal differences and having only the smaller form before him, erects for it a new species, *C. americanus*. Of course, if this is to include the whole assemblage representing *C. viridis* in America, the name *C. ingens* is prior. If not, the later name may be revived for the form corresponding to *C. gigas* of Europe.

To judge from the figures in Claus' *Das Genus Cyclops*, the European form is subject to a very wide range of variation, for *C. furcifer*, afterwards regarded as a simple varietal form of *C. brevicaudatus*, has the stylets and antennæ greatly elongated. Unfortunately the details of the armature of the feet are not given by Claus or most of the authors following him.

Var. a. ***Cyclops americanus** Marsh.

PLATE XIV.

Subspecies Americanus Marsh.

We quote Marsh's description entire:

"Cephalothorax oval, the first segment being about half its total length. Antennæ 17-jointed, about as long as the first cephalathoracic segment. Abdomen rather slender, the last segment armed on its posterior border with small spines. All the abdominal segments in immature individuals are strongly pectinate posteriorly. Furca about three times as long as its average breadth, the lateral spine situated well towards the end. The first and fourth terminal setæ are short, slender and plumose, nearly equal in length. Of the internal setæ, the outer is a little more than three-fourths of the length of the inner. The armature of the terminal joints of the swimming feet is as follows:

FIRST FOOT.

Outer ramus	ex. 3 spines. ap. 2 setæ. in. 2 setæ.	Inner ramus	ex. 1 seta. ap. 1 spine, 1 seta. in. 3 setæ.

SECOND AND THIRD FEET.

Outer ramus	ex. 3 spines. ap. 1 spine, 1 seta. in. 3 setæ.	Inner ramus	ex. 1 seta. ap. 1 spine, 1 seta. in. 3 setæ.

FOURTH FOOT.

Outer ramus	ex. 3 spines. ap. 1 spine, 1 seta. in. 3 setæ.	Inner ramus	ex. 1 seta. ap. 2 spines. in. 2 setæ.

"Fifth foot two-jointed, basal joint very broad, armed with one seta. Terminal joint armed with a seta and a blunt spine. Length 1.2 mm."

The points of difference consist in the fact that the antennæ are shorter than European *viridis*, reaching only to the second instead of to the third thoracic segment, and that the armature of fourth feet are very unlike the figures and descriptions of European authors. Brady is the only author who figures these parts, and these figures are evidently careless, for the antennæ on the same plate have a supernumerary joint. We have examined a number of specimens of this species from distant parts of the United States, and find, with Marsh, the armature constant or but slightly variable. The proportions of the apical spines of the inner ramus of the fourth foot are the reverse of those given in his figure. The size varies remarkably, passing into the large variety. 1.4 mm. is an an average measurement exclusive of setæ.

Var. b. ***Cyclops ingens** Herrick.

PLATE XXV, FIGS. 1-8.

This is the largest form yet encountered in America and is rarely seen. It is a simple exaggeration of the last, there being no obvious distinctions except the size. It is occasionally over 4.0 mm. long including the setæ or about 3.0 mm. excluding them.

It may be noticed that the males of this group have a well-developed sixth foot. The antennæ are strongly modified and amply spined, as shown in the figure. A series of hyaline plates near the joint are well developed.

***Cyclops vernalis** Fischer. (Fide Schmeil.)

Fischer '53; Sars '63 (C. lucidulus); Claus '63 (C. elongatus); Heller '70 (C. elongatus); Rehberg '80[1] (C. elongatus and C. lucidulus); Cragin '83 (C. elongatus); Herrick '84 (C. elongatus and lucidulus); Daday '85[5] (C. lucidulus); Sostaric '88 (C. lucidulus); Schmeil '91 (C. elongatus) and '92; Richard '91; Brady '91 (C. elongatus).

We cannot, of course, enter the perplexing synonomy which has been very carefully studied by Schmeil, and we hope that it may now be considered settled. The not quite unexpected discovery that a 17-jointed species may, under certain conditions, become 18-jointed rests on the same kind of evidence which Schmeil rejects in respect to our own statements in the case of other species, and offers a certain probability in favor of the frequent occurrence of imperfectly mature but oviparous females, which he rejects without making the necesary investigation by which he might easily have convinced himself of its reality. However, we are fain to accept the evidence that *C. elongatus* Claus is but a "post-imago" of *C. lucidulus* Sars. Still it is not to be forgotten that other species may sporadically develop 18-jointed antennæ and then might lay claim to be considered *C. elongatus*.

Cephalothorax rather long, tapering caudad, fourth and fifth segments somewhat produced. Abdomen more than half as long as thorax, first segment as long as the remainder. Stylets as long as the two preceding segments plus half the next. Median apical setæ nearly equal, as are the outer and inner, which are both short. The antennæ are shorter than the first thoracic segment, either 17-jointed or 18-jointed by the subdivision of the seventh joint. Schmeil claims to have found some in which the right antenna is in one condition and the left in another. Fifth foot two-jointed, basal segment short, broad, bearing a plumose hair; second joint small, cylindrical, armed with a short spine and a plumose seta. Receptaculum opening transversely narrowly elliptical. Length 1.2 to 1.7 mm.

Cyclops robustus Sars.

I simply quote the original description:

"Corpus breve et robustum depressiusculum, segmento 1 mo lato et antice æque rotundato, ceteris ad latera sat exstantibus, ultimo quam segmento 1 mo abdominali multo latiore. Rami caudales vix divergentes longitudinem segmentorum antecedentium 2 superantes setis apicalibus fortibus et fere aculeiformibus, intermediarum interiore quam exteriore multo longiore longitudinem abdominis fere æquante versus medium sparsim dein dense ciliata, ceteris duabus brevissimis et fere ejusdem longitudinis. Antennæ 1 mi paris 17 articulatæ, breves et crassæ segmento 1 mo corporis breviores. Articulus ultimus rami exterioris pedum natatoriorum latus extus aculeis 3, intus setis 4 instructus; seta marginis exterioris articuli ultimi rami interioris in pedibus 2di—4ti paris in aculeum fortem conformata; aculeique apicales 2 ejusdem articuli in pari 4to subæquales. Pedum 5ti paris articulus ultimus parvus intus aculeo brevissimo et rudimentari armatus. Sacci oviferi ovales abdomini appressi. Longit. circit. $1\frac{1}{2}$ mm."

* **Cyclops parcus** Herrick.

PLATES XX, FIGS. 12-15; XXI, FIG. 22; XXIII, FIG. 8; XXXIV, FIGS. 1-8.

Herrick '82 and '84; Marsh '93.

This species, which is very near to *C. vernalis* and *C. viridis*, has more superficial resemblances to *C. pulchellus*, which it also resembles in the form of the swimming feet, occurs in small and stagnant pools. The antennæ are shorter than or about as long as the first thoracic segment, the last two segments of which are acute. The antennules are rather short. Labrum narrow, projecting below into obtuse angles, cutting edge with nine small teeth. The terminal joint of the larger branch of the maxilliped bears four hairs. The second joint has a moderately large dactyl, the movable finger of which is small and sparsely spiny, the immovable finger is ornamented by an oblique series of blunt prominences and a small seta at its base. The armature of the swimming feet is as follows:

FIRST FEET.

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	2 setæ.		ap.	1 spine, 1 seta.
	in.	2 setæ.		in.	3 setæ.

SECOND FEET.

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	1 spine, 1 seta.
	in.	3 setæ.		in.	3 setæ.

FOURTH FEET.

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	2 equal spines.
	in.	3 setæ.		in.	2 setæ.

The fifth foot is two-jointed, the basal joint being short, broad, and armed with one seta, while the apical segment is short, fusiform with a long seta and short spine. The foot is very like that of *C. viridis*, but the basal joint is smaller. The abdomen is rather slender, the first joint being rather longer than the remaining joint exclusive of the stylets. The latter in the average form are rather short and the lateral seta is over one-fifth their length from the apex. The outer apical seta is three-fourths the length of the inner. The inner median seta considerably longer than the outer. In addition to the ordinary form with short stylets there are frequently found others which have the stylets considerably elongate. Such a form is figured in Plate XXXIII. In this case the stylets are six times as long as wide and equal in length the last two and half of the next abdominal segments. The small lateral spine is more than a fourth the length from the end, and there is a slight unserrated offset at the basal one-fourth externally. The inner seta is nearly as long as the stylet, the outer two-thirds as long. The inner median seta is three times as long as the stylet, and the outer is but twice as long as the stylet. The antennæ in this form are about as long as the first segment, which forms nearly half the length of the thorax. The abdomen without the stylets is half the length of the thorax.

The form of the receptaculum is transversely oval, very similar in fact to *C. vernalis*. Unfortunately the printer in the preceding edition made the description of Plate 24 so read that the figure of this structure was credited to *C. adolescens*.

Length 1.4 to 1.5 mm. The following measurements of the elongate form are given to illustrate the proportions: Length 1.37 mm., thorax 0.85 mm., first segment 0.41 mm., abdomen (exclusive of stylets) 0.41 mm., stylets 0.19 mm., antennæ 0.45 mm., longest seta 0.50 mm.

It is possible that the elongate form, which is found in association with the type, is to be regarded as a post-imago. There is danger of confusing this form with *C. brevispinosus* Herrick, and it is not certain that this has not already happened to some extent.

*Cyclops brevispinosus Herrick. 1884.

PLATES XXIII, FIGS. 1-4; XXIV, FIGS. 7-12.

This species may be regarded as the pelagic representative of *C. parcus*. In the original description the following differences were noted. The form is more slender and the stylets are greatly elongated, the outer caudal seta is reduced to a short ciliate spine, and the fourth foot is differently armed and the receptaculum is somewhat different in form.

Marsh says that one might infer from my statement that the armature of the swimming feet is the same as in *C. parcus*, but how this could be possible in the face of the plain statement of difference and figure of the fourth foot it is hard to see.

The first segment of the compact thorax is half its entire length and the antennæ are rather shorter. The abdomen is rather slender and tapering. The stylets are 4.5 times as long as wide, and the small lateral seta is more than two-thirds its length from the base. The outer terminal seta is transformed into a very short stout serrate spine, shorter than the inner seta and one-third as long as the stylets. The outer median seta is less than three times as long as the stylet and is naked for more than half its length, when it is suddenly narrowed and very closely pectinate to the end. The inner median seta is almost exactly three times as long as the stylet, and is sparsely pectinate for its middle third and closely so for its apical third.

The armature of the feet is as follows:

FIRST FOOT.

Outer ramus	ex.	3 spines.	Inner ramus	ex.	1 seta.
	ap.	2 setæ.		ap.	1 spine, 1 seta.
	in.	2 setæ.		in.	3 setæ.

SECOND FOOT.

Outer ramus	ex.	3 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	1 spine, 1 seta.
	in.	3 setæ.		in.	3 setæ.

THIRD FOOT.

Outer ramus	ex.	3 spines.	Inner ramus	ex.	1 spine.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	3 setæ.		in.	3 setæ.

FOURTH FOOT.

Outer ramus	ex.	3 spines.	Inner ramus	ex.	1 spine.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	3 setæ.		in.	2 setæ.

The basal segment of the fifth foot is little expanded and bears one seta while the short second joint has an apical seta and a small lateral external spine. Formula for antennæ, – ⌣ ⏑ – ⏑⏑ – ⏑ ⏑ ⏑ ⏑ ⌣ ⏑ ⏑ ⌣ ⌣ –. Antennules rather short. Length 1.0 mm. Marsh suggests that this may be a pelagic form of *C. viridis* var. *Americanus*, in which case *C. parcus* would become a variety of the same species.

Cyclops uniangulatus Cragin.

Cragin '88; Herrick '84.

Cragin was not conversant with the description of *C. parcus*, with which his description agrees save in one point. It differs from *C. parcus* in having three inner setæ on the terminal joint of the outer ramus of the first foot. It would be officious to suggest a possible oversight here, but *C. parcus* has only two in type specimens (though in all this group the corresponding ramus of the second foot has three setæ), so that at present the two must be kept distinct.

* **Cyclops leuckarti** Claus.

PLATES XVI; XVIII, FIGS. 1, A-J; XXIV, FIGS. 2-6.

Claus '57 and '63; Sars '63; Poggenpol '74 (simplex); Uljanin '75 (tennicornis); Hoek '78 (leeuwenhœkii); Herrick '83 (tennissimus) and '84 (simplex and leuckarti); Daday '85 (simplex, pectinatus, and leuckarti); Vosseler '86 (simplex); Herrick '87 (simplex); Thallwitz '90 (simplex); Lande '90 (simplex); Schmeil '91 and '92; Richard '91; Forbes '91 (edax); Brady '91 (scourfieldi); Marsh '92.

"DESCRIPTION OF THE FEMALE: The form is very slender, an average individual measuring between 0.95 and 1.0 mm. exclusive of the caudal setæ. The following detailed measurements of a specimen measuring 0.976 mm. will serve to exhibit the proportions of the parts: First thoracic segment 0.30 mm., second segment 0.08 mm., third segment 0.08 mm., fourth segment 0.056 mm., fifth segment 0.024 mm.; first (apparent) abdominal segment 0.16 mm., second segment 0.08 mm., third segment 0.048 mm.; caudal stylets 0.088 mm., outer seta 0.08 mm., outer median 0.30 mm., inner median 0.46 mm., inner 0.20 mm., dorsal 0.06 mm.; the lateral seta is 0.036 mm. from the end. The antennæ reach nearly to the base of the thorax when reflexed, and are quite strong. They resemble those of *C. tennicornis* in several particulars, but since it is desirable to distinguish this species with the greatest possible accuracy, the following numbers are given to express the relative length of the several segments, beginning with the first: $_1 20$, $_2 5$, $_3 3$, $_4 10$, $_5 7$, $_6 4$, $_7 11$, $_8 5$, $_9 5$, $_{10} 5$, $_{11} 7$, $_{12} 7$, $_{13} 5$, $_{14} 6$, $_{15} 10$, $_{16} 15$, $_{17} 14$. The fourth, eleventh, fourteenth and fifteenth segments bear the longest setæ. The last two segments are armed with a knife-like ridge similar to that found in *C. tennicornis*. This ridge is serrulated on the last segment, and near the end is cut by a deep incision so that the terminal part is like a hook notched upon its convex outer part. The antennules are slender and but moderately spinous, the first three segments being almost exactly equal (0.06 mm.), while the terminal segment is as long as the basal segment of the antennæ (0.08 mm.). The labrum is armed with thirteen small teeth. The larger maxilliped is pearled on the posterior margin of its largest segment. The armature of the terminal joints of the feet is as follows:

First Foot.

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	2 setæ.		ap.	1 spine, 1 seta.
	in.	2 setæ.		in.	3 setæ.

Second and Third Feet.

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	1 spine, 1 seta.
	in.	3 setæ.		in.	3 setæ.

Fourth Foot.

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	3 setæ.		in.	2 setæ.

"The fifth foot is two jointed, the basal joint is short and bears a tubercle carrying a seta 0.06 mm. long, the terminal segment is terete and bears a spine 0.10 mm. long apically and another as long upon the middle of its inner side. The cement gland is of peculiar shape, resembling that of *C. parcus* exactly. The last segment of the abdomen is spiny upon the posterior margin above. The color is usually pale, but may be ornamented with bluish suffusions.

"Though closely allied with the species in America identified with Sars' *C. oithonoides* there can be no doubt that two forms occur, this one being nearly exactly like the species described by Hoeck as *C. leeuwenhœkii*. The description and drawings are given as a basis upon which to distinguish other allied species. The form from the Southern States originally called *C. tenuissimus* is probably this species, though possibly distinct."

I have quoted our own original descriptions, correcting misprints in the armature of the feet, which was, however, correctly given in the figures. Schmeil's figure of the armature of the antennæ is faulty in not representing the teeth upon the lamina although the excision is clearly shown.

The form described in the previous edition as *C. oithonoides* Sars, has not been re-examined and I am inclined to believe that it is but a small pelagic form or variety of the typical *C. leuckarti*. *Cyclops oithonoides* is essentially a brackish water form and with its variety *hyalina* Rehberg, and *C. dybowskii* Schmeil, constitutes a very close group whose members are quite variable and occur under such conditions as to lead one to suppose that they constitute a compound specific group whose members have not yet attained their autonomy.

The original description of the American form is appended:

"This most interesting species occurs under peculiar circumstances. It is perhaps the rarest member of the genus, and seems, beyond a doubt, nocturnal in its habits. It was first found by Sars in saline water, and named, on account of its slender form, from the marine *Oithona*. A similar species which, though about half as large, is hardly distinct, was found by Rehberg near Bremen. Rehberg men-

tions particularly that it was found oftener at night than during the day. In America a similar species was described from near Paducah, Ky., under the name *C. tenuissimus;* but the possibility of identity with the Scandinavian species seemed excluded by the habitat. A gathering taken at night from one of the lakes near Minneapolis contained a few specimens of similar characters, and there no longer seems to be a doubt of the identity or very close relation between these forms.

"The antennæ are longer than described for *C. tenuissimus*, nearly equalling the thorax. The last joint of the antennæ is short, but the toothed character was not noted. The fifth feet are small, the spines are very long and slender. The margins of the abdominal segments are irregularly toothed. The species will be confused with no other. It is marked with blue in spots. Length 0.5 to 1.0 mm."

Cyclops scourfieldi Brady.

Brady '91.

It is very difficult to determine whether we have in this species a variety of *C. leuckarti* or a distinct species. Brady identifies it with Sars' *C. leuckarti*, which is regarded as distinct from Claus' *C. leuckarti*. Schmeil has decided, after examination of Sars' specimens, that they belong to *C. leuckarti* Claus, and are the same as *C. simplex* of other authors. Under these circumstances there would seem to be no reason for hesitating in referring *C. scourfieldi* to *C. leuckarti* were it not that the figure of the fourth foot given by Brady differs in armature from that of Schmeil, and Brady fails to remark the striking armature of the last joint of the antenna. If Schmeil is correct in saying that the pearling or crenulation of the posterior margin of the maxilliped is diagnostic of *C. leuckarti*, the matter would be settled at once, for Brady clearly figures it. On the whole, we incline to believe that Brady's figure incorrectly shows a seta where there should be a spine at the apex of the outer ramus of the fourth foot and that he has overlooked the hyaline plate on the antenna. He says, however, "the character which, so far as I know, distinguishes at once *C. scourfieldi* from all other species is the presence, on the second joint of the posterior maxilliped, of a series of short marginal spines." Length 1.4 mm. It may be added, that, in a figure of what is considered a variety of *C. scourfieldi*, the armature of the outer ramus is figured as it occurs in *C. leuckarti*, while that of the inner ramus is obviously inaccurate.

***Cyclops oithonoides** Sars.

Very slender, thorax twice as long as wide, abdomen narrow, length compared to that of the thorax as 9:13. Stylets about twice as long as wide, strongly divergent, with short setæ; the lateral seta near the

middle of the outer margin, outer terminal seta short, the outer median seta as long as the innermost, inner median a little longer. Antennæ long, slender, reaching the middle of the fourth segment, some of its setæ greatly elongate, formula, – ⌣ – – ⌣ – – – – – ⌣ – – – – –; the last two segments have a narrow hyaline membrane which is entire. Armature of fourth feet as follows:

Outer ramus	ex. 2 spines.	Inner ramus	ex. 1 seta.
	ap. 1 spine, 1 seta.		ap. 2 spines.
	in. 3 setæ.		in. 2 setæ.

Fifth foot with short, broad basal joint and an oval elongate apical segment bearing two setæ. The receptaculum is elongate, with two curved proximal branches. Length 0.87 mm.

Cyclops dybowskii Lande, which seems hardly a good variety of *C. oithonoides*, is said to differ from it in the following major points: The antennæ are shorter and more stout, minute differences occur in the chitin plates which unite the base of the third pair of feet and the lamella of the fifth foot. In fact the differences are less than may be found in any of our species when collected in different stations.

Cyclops bisetosus Rehberg.

PLATE XXIII, FIGS. 9-11.

Sars '62 (bicuspidatus); Rehberg '80; Forbes '82 (insectus); Herrick '84 (insectus); Schmeil '92.

Cephalothorax depressed, first segment of moderate size, angles of segments rounded. Abdomen long, its length to that of the thorax as 26 : 39. First segment enlarged, as long as the following. Stylets long, lateral seta near the end, small teeth externally and the basal one-fourth, inner and outer terminal setæ small, median setæ rather long, the longer as long as the abdomen, the shorter two thirds as long. Antennæ 17 jointed, little longer than the first thoracic segment. Fifth foot resembling that of *C. vernalis*, with a small but broad basal joint with a long lateral seta, apical segment with a long seta and short spine. The swimming feet are armed with three spines externally (*C. pulchellus* has but two). Length 1.3 mm. As figured by Schmeil, this species differs strongly from *C. bicuspidatus* and is nearer to *C. pareus*. Whether *Cyclops insectus* Forbes, is really this species must, in the absence of authentic specimens, be left open.

Cyclops strenuus Fischer.

PLATE XXIII, FIGS. 12, 13.

Fischer '51; Lilljeborg '53 (quadricornis); Claus '57 and '63 (brevicaudatus, and furcifer); Sars '63 (scutifer, abyssorum, and strenuus); Lubbock '63 (brevicaudatus, and clausii); Fric '72 (brevicaudatus); Uljanin '75 (vicinus, and fedtschenkoi);

Hoek '78 (brevicaudatus); Brady '78 (pulchellus, and strenuus); Herrick '84; Daday '85 (claudiopolitanus, hungaricus, paradyi, elongatus, and strenuus); Vosseler '86 (lucidulus, bodamicus, and strenuus); Sostaric '88 (quadricornis); Thallwitz '90 (lucidulus); Lande '90 (vicinus, and strenuus); Richard '91; Brady '91 (abyssorum, vicinus, and strenuus); Schmeil '91 and '92.

This species is said to be one of the most abundant on the continent of Europe and assumes a great variety of forms whose relations are far from clearly understood.

The cephalothorax is large, and the fourth and fifth segments project laterally. The abdomen is five-eighths as long and tapers distally. The stylets are slender, divaricate, longitudinally ridged above and about as long as the last three segments of the abdomen. The two median setæ are relatively short, the inner apical being as long as the stylet and twice as long as the inner apical or more. Lateral seta small, not far from the end. The antennæ reflexed scarcely reach the base of the third segment. The fifth foot is two-jointed, the basal segment being small, nearly quadrangular and armed with a short ciliate seta. The apical segment is longer, with one long apical seta and a lateral spine. Length 1.5 to 2.5 mm. Schmeil observed a specimen 3.2 mm. long. Schmeil unfortunately places no reliance on the armature of the feet, which, as Marsh also has shown, are of great importance and are fairly constant, and his figures and descriptions help but little in solving the perplexities of this multiform species. In this we are at present the less interested in that the species has not as yet been recognized in America.

Brady gives greater detail and fails to offer valid reasons for separating *C. abyssorum* and *C. vicinus* from *strenuus*, though he inclines to believe *C. abyssorum* a deep sea variety of *C. vicinus*=*C. pulchellus* of his monograph.

The formulæ for the feet in *abyssorum* are as follows:

First Foot.

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 2 setæ.		ap.	1 spine, 1 seta.
	in.	3 setæ.		in.	3 setæ.

Third Foot.

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	1 spine, 1 seta.
	in.	4 setæ.		in.	3 setæ.

Fourth Foot.

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	3 setæ (4 setæ?)		in.	2 setæ.

The only difference of importance between the two species seems to be the shorter antennæ of *C. vicinus*.

Cyclops lacustris Sars.

Cephalothorax sub-ovate, truncate in front. Abdomen of equal width throughout; caudal stylets longer than the last two segments of the abdomen; terminal setæ of moderate size, inner three times as long as the outer, internal pair nearly equal. Antennæ as long as the first two joints of the body. The inner ramus of the fourth foot has the exterior spine very small. Second joint of fifth foot small and external spine minute. Length 1.5 mm. It is suggested by Schmeil that this species, with *C. scutifer* and *C. abyssorum*, should be regarded as synonyms for *C. strenuus*. Upon this matter I can offer no opinion, nor does the brief description repeated above help the matter much.

* **Cyclops pulchellus** Koch.

Koch '41; Sars ' 57; Claus '57 and '63 (bicuspidatus); Heller '70 (bicuspidatus); Fric '72 (bicuspidatus); Hoek '78 (bicuspidatus); Rehberg '80[1], and 80[2], (helgolandicus); Vejdovsky '82; Herrick '83 (pectinatus); Forbes '82 (thomasi); Daday '85 (entzii, and pulchellus); Vosseler '86; Sostaric '88; Thallwitz '90; Lande '90; Schmeil '91 and '92 (bicuspidatus); Richard '91 (bicuspidatus); Brady '91 (bicuspidatus, and thomasi); Forbes '91 and '93 (thomasi); Marsh '93

Schmeil and Marsh agree in regarding *C. thomasi* of America as identical with *C. cuspidatus*, and in this we are inclined to concur in spite of certain differences in variable characters.

Instead of the original description of Forbes, we reproduce that given in the *Report on the Invertebrate Fauna of the Yellowstone Park*. It is to be noticed that Forbes regarded, in his earlier report, certain spines as apical (in his description of the feet) which may be more logically described as lateral.

A long and slender species, with 17 jointed antennæ, oval cephalothorax, somewhat closely articulated, slender abdomen, very long and slender caudal rami, and two developed setæ to each ramus, the longer of which is about twice as long as the shorter.

The cephalothorax is widest near the middle, its greatest width a little more than half its length. Posterior angles not prominent or produced, except those of the last segment, which are slightly produced outwards. Sides of the first segment subparallel, rounding slightly toward the front, the segment itself twice as long as the other segments combined; the second segment shorter than the third, but longer than the fourth; the fifth reduced to a narrow linear band, as seen from above, the extremities of which project a little beyond the lateral outline. Abdomen with furca, a little shorter than the cephalothorax, its greatest width one-fourth of its length, including furca. First segment in the female as long as all the others together, broadest in front, its lateral outlines emarginate behind the anterior angles. Posterior margin of last segment serrate beneath and at sides;

those of other abdominal segments smooth. Furca as long as the last three segments, the width of the rami about one-seventh of their length. The inner of the two longer setæ as long as the entire abdomen, the outer of the two half that length. The outermost of the terminal setæ two-thirds the length of the inner, i. e., about one-fourth the length of the caudal ramus. Rami slightly curved outwards, with one large spine and a few small ones a little beyond the middle of the outer surface, and a vertical comb of small spines at one-fourth the distance from the proximal end.

Antennæ of the female moderately robust, reaching about to the middle of the third segment, without accessory structures or appendages, the three terminal segments gradually increasing in length, the antepenult two-fifths of the last. The two segments preceding the former, taken together, shorter than the last segment and about equaling the penultimate.

The armature of the swimming feet is as follows:

First Feet.

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	2 setæ.		ap.	1 spine, 1 seta.
	in.	2 setæ.		in.	3 setæ.

Second Feet.

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	1 spine, 1 seta.
	in.	3 setæ.		in.	3 setæ.

Third Feet.

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	1 spine, 1 seta.
	in.	3 setæ.		in.	3 setæ.

Fourth Feet.

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	3 setæ.		in.	2 setæ.

Fifth pair of legs of two segments, the basal segment about as long as broad, with a strong plumose spine from the outer angle, the terminal segment cylindrical, twice as long as broad, with two terminal setæ, the outer of which is as long as the seta of the preceding segment, the inner a little more than half the length. Total length, without setæ, 1.33 mm., greatest depth a trifle less than one-third the length of the cephalothorax. Yellowstone lake, Great Lakes, etc.

C. pulchellus is said to be pre-eminently the pelagic species of the Great Lakes.

* **Cyclops pulchellus** var. **navus** Herrick.

Herrick '82 (C. navus), and '84 (C. pulchellus var. navus); Marsh '93 (C. navus).

This form or variety inhabits shallow pools and is larger than *C. pulchellus*. It also has much shorter stylets and differently proportioned antennæ, etc. Length 1.5 mm., thorax 0.9 mm., abdomen 0.6

mm., stylets 0.14 mm., last two abdominal segments 0.16 mm., antennæ 0.7 mm., first segment of body 0.5 mm. The basal segment of the antennæ is long and ornamented with several transverse series of spines; the last two segments are equal and longer than the preceding. The armature of the first and fourth feet is identical with *C. thomasi*, as is the form of the female openings and the fifth feet. The form of the first feet, caudal stylets and other details were correctly figured on Plate V of the *Cyclopidæ of Minnesota*.

Specimens of *Cyclops pulchellus (thomasi)* were obtained from a cistern which is supplied solely by rain-water. The eggs must have been introduced in ice which had been placed in the cistern at least a year previously. The cistern is entirely dark, so that these animals must have been deprived of light for many generations. The general color was, of course, very white; the eye spots were pale, but present with some pigment and the lenses. No noticeable alteration in form had resulted.

* Cyclops minnilus Forbes.

Forbes '93.

A small slender species with 17 jointed antennæ, with narrow and loosely articulated cephalothorax and salient thoracic angles, slender abdomen, long narrow furca, and but two well-developed caudal setæ for each ramus. The antennæ reach to the posterior margin of the second distinct segment, and are of very nearly the length of the abdomen (excluding the caudal setæ). The greatest width of the thorax is contained two and one third times in its length, and the furca is very nearly half the length of the remainder of the abdomen. The diameter of a ramus is about one seventh its length.

The rudimentary inner caudal seta is a trifle longer than the outer, and about a third the length of the ramus: the longest seta as long as abdomen and furca; the next in length less than half the longest. The armature of the legs is as follows:

First Feet.

Outer ramus	ex.	1 seta.	Inner ramus	ex. 1 seta.
	ap.	1 spine 2 setæ.		ap. 1 spine, 1 seta.
	in.	2 setæ.		in. 3 setæ.

Second Feet.

Outer ramus	ex.	2 spines.	Inner ramus	ex. 1 seta.
	ap.	1 spine, 1 seta.		ap. 1 spine, 1 seta.
	in.	3 setæ.		in. 3 setæ.

Third Feet.

Outer ramus	ex.	1 spine.	Inner ramus	ex. 1 seta.
	ap.	*2 spines, 1 seta.		ap. 1 spine, 1 seta.
	in.	3 setæ.		in. 3 setæ.

Fourth Feet.

Outer ramus	ex.	1 spine.	Inner ramus	ex. 1 seta.
	ap.	*2 spines, 1 seta.		ap. *2 spines.
	in.	3 setæ.		in. 2 setæ.

* In each case one spine twice as long as the other.

Rudimentary legs of fifth pair distinctly articulated, basal article with a long seta at its outer distal angle, and second article with two setæ at its blunt tip, the outer the longer. From Duck lake.

Neither figures nor measurements are given, and the form of the fifth foot is left to conjecture. In this difficult section of the genus it is very hard to place species even when all the details are clearly before us. The original description is reproduced with only verbal alteration for the sake of brevity.

* **Cyclops forbesi** Herrick.
Forbes '93 (serratus*).

A very long, narrow, loosely articulated species with strikingly salient thoracic angles. Cephalothorax broadest far forward and lobed in front, between the 17-jointed antennæ. Abdomen long and slender, with very long and narrow caudal rami, and but two developed setæ to each ramus. The first segment is but little longer than wide (eight to seven), is broadest across the middle, and excavate in front at the base of each antenna, leaving a thick, median, projecting lobe. The second segment is nearly a fourth as long as the first, and but little narrower, broadest across its posterior angles, which, though blunt, are so strongly salient that the lateral margins are decidedly sinuate. The third segment is as long as the second, but narrower, and with its sides more nearly parallel. The fourth and fifth segments are progressively shorter and narrower, the latter being trapezoidal, as seen from above, and separated from the first abdominal segment by a deep acute emargination.

The abdominal segments are as long as the cephalothoracic segments two to five taken together, and the furca is as long as the last three segments. The first segment of the abdomen is broadest in front, where its width is nearly as great as its length. The second is as broad as long, the third and fourth equal, the fifth a little shorter, the last with a row of fine spinules around the base of the rami. The width of each ramus is contained nearly eight times in its length. Besides the lateral spine, situated a little before the posterior third of the ramus, there is a cluster of two or three minute spines at its anterior fourth. The outer and inner terminal setæ are reduced to short subequal spines about twice as long as the ramus is wide. The other setæ are slender, plumose, the inner nearly twice as long as the outer. The antennæ are rather stout and short, 17-jointed, reaching to the end of the second segment. They are without special structures or appendages. [This probably means armed as usual, but without knife ridges or spurs.] Armature of the legs as follows:

* This name is preoccupied by *C. serratus* Pratz. 1866.

FIRST FEET.

Outer ramus	ex.	1 spine.	Inner ramus	ex. 1 seta.
	ap.	1 spine, 1 seta.		ap. 1 spine, 1 seta.
	in.	2 setæ.		in. 3 setæ.

SECOND FEET.

Outer ramus	ex.	1 seta.	Inner ramus	ex. 1 seta.
	ap.	1 spine, 1 seta.		ap. 1 spine, 1 seta.
	in.	3 setæ.		in. 3 setæ.

THIRD FEET.

Outer ramus	ex.	1 spine.	Inner ramus	ex. 1 seta.
	ap.	2 spines, 1 seta.		ap. 1 spine, 1 seta.
	in.	3 setæ.		in. 3 setæ.

FOURTH FEET.

Outer ramus	ex.	1 spine.	Inner ramus	ex. 1 seta.
	ap.	2 spines, 1 seta.		ap. 2 spines.
	in.	3 setæ.		in. 2 setæ.

The fifth feet are two-jointed, the basal joint broad, quadrate, with a seta at its outer angle; the second cylindrical, with one long and one short seta at tip. Length, without setæ, 1.34 mm.

*Cyclops signatus Koch.

PLATES XX, FIGS. 8-11, 21; XXI, FIG. 16.

Jurine '20 (monoculus quadricornis albidus and m. g. fuscus); Koch '41 (signatus, and annulicornis); Baird '50 (quadricornis var. b and var. c); Claus '57 and '63 (coronatus and tenuicornis); Sars '63 (annulicornis, tenuicornis, and signatus); Lubbock '63 (coronatus, and tenuicornis); Fric '72 (coronatus, and tenuicornis); Poggenpol '74 (clausii); Uljanin '75; Hoek '78 (coronatus, and signatus) Brady '78 (tenuicornis, and signatus); Cragin '83 (tenuicornis, and C. signatus fasciacornis); Herrick '82 and '84 (tenuicornis); Daday '85 (tenuicornis, and signatus); Vosseler '86 (tenuicornis, and signatus); Forbes '87 (gyrinus); Sostaric '88 (fuscus); Thallwitz '90; Lande '90; Schmeil '91 (albidus); Brady '91; Richard '91 (fuscus, annulicornis, and tenuicornis); Schmeil '92 (fuscus, and albidus); Marsh '92; Turner '92 (tenuicornis).

Of the identity of the two varieties which have so long been recognized as distinct species (*C. tenuicornis* and *C. coronatus*) the writer has little doubt. The development history has been traced sufficiently to settle this point. This combination was first made by the writer, and not by Brady, as Marsh implies. Cephalothorax large and broad, considerably longer than the abdomen. First thoracic segment large, more than half as long as the whole thorax. Abdomen rather short, cylindrical. Stylets short and not tapering, shorter than the preceding abdominal segment. Setæ very plumose, three of them long, the longest being about as long as the abdomen, the innermost being nearly half as long and the outermost apical seta short. In the male the first thoracic is much longer and the abdomen relatively shorter. Antennæ long and the terminal joints attenuated, the last three being armed by hyaline plates. Fourth foot with the following armature:

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	4 spines.		in.	2 setæ.

The spines are serrulate and the setæ very plumose. Fifth foot two-jointed, basal joint longer than wide, with a series of small teeth and a long seta, apical joint with three plumose setæ. Color bluish or banded, the antennæ especially banded on the fifth to sixth and twelfth to fourteenth joints.

* Cyclops signatus var. coronatus.

PLATE XV, FIGS. 1-4.

First segment of thorax long, its length to that of the entire thorax about as 1 : 1.50. Last segment of antennæ with the proximal portion of its hyaline plate coarsely serrate. Caudal stylets short, ciliated internally, length to width as 1.25 : 1. Second segment of antennules short. Inner apical seta of stylets one-third longer. Color marked.

* Cyclops signatus var. tenuicornis.

PLATES XV, FIGS. 5-7; XX, FIGS. 1-7; XXXIII, FIGS. 1, 2.

First segment of thorax shorter, its length to that of the entire thorax as 1 : 1.9. Last segment of antennæ with unserrated lamella. Caudal stylets longer, length to width as 2.1 : 1, inner aspect not ciliated. Outer apical seta half as long as inner. Second segment of antennules longer. Color variable but always banded or splotched. It is also generally true that the ovisacs in the present variety are more strongly divaricate than in the variety *coronatus*.

Schmeil also finds differences in the form of the receptaculum and sexual elements.

Over against the above differences must be set the close agreement in the armature of the feet and the fact that the late stages of *coronatus* remain to be described while it is always associated with *C. tenuicornis*, generally in greater numbers. The greater hairiness and stronger serrations of *C. coronatus* are characters suggestive of advanced age, as has been observed in other species. *C. tenuicornis* is frequently found without *C. coronatus*, but the reverse has not been found true in our experience. Finally attempts at experimental rearing of *coronatus* from *tenuicornis* have been made, and, while some possible sources of error unfortunately crept in, yet I am morally convinced that the apparent transformation was genuine.

Dr. Schmeil discusses this question at length without adding anything to the evidence. He adduces the differences in structure, though he fails to find anything but such as consist in altered proportions of structures common to both. He claims that embryos of

C. coronatus are "allgemein bekannt," though adding that Rehberg admits that the young of the two species cannot be distinguished until the last moult, which seems to show that the late larvæ of *C. coronatus* are hardly "allgemein bekannt" even in Europe. Finally Schmeil denies the possibility of sexual precosity with the general statement that "Auch mir ist trotz der grössten Aufmerksamkeit unter den vielen Tausenden der von mir beobachteten Copepoden noch nicht ein einziges Mal eine solche Larve mit Eiballen zu Gesicht gekommen." To this we can only say that such larvæ have been frequently seen during the last ten years, though only under certain conditions of time and place. It is hoped to furnish conclusive evidence on this head soon if it is really needed. We had supposed that such precosity was now a well-recognized fact. It is to be hoped that careful embryological and biological studies may be instituted upon the *Copepoda*.

Cyclops languidus Sars.

PLATE XVII, FIGS. 10, 11.

Sars '63; Herrick '84; Schmeil '91 and '92; Richard '91.

This species has not yet been encountered in America, and from the extended discussion of Schmeil we still think there is considerable probability that this form is an illustration of retarded development of some 17-jointed species, perhaps *C. bicuspidatus*.

Cephalothorax attenuated anteriorly and posteriorly, narrow. Abdomen slender. Stylets exceeding in length the two preceding segments. Lateral seta at two-thirds the length from the base, two median setæ long, two lateral apical setæ very short, the outer a serrate spine.

Antennæ slightly longer than the first segment, with short setæ, 16-jointed by the more or less complete fusion of the third and fourth segments. First feet with both rami two-jointed, formula:

Outer ramus	ex.	3 spines.	Inner ramus	ex.	1 seta.
	ap.	2 setæ.		ap.	1 spine, 1 seta.
	in.	3 setæ.		in.	3 setæ.

Second foot with a three-jointed outer and two-jointed inner ramus. Formula as follows:

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	1 spine, 1 seta.
	in.	3 setæ.		in.	4 setæ.

NOTE.—The following measurements will serve to illustrate the usual proportions of variety *tenuicornis:* Total length, including stylets, 1.4 mm., first segment of thorax 0.5 mm., whole thorax 0.85 mm., abdomen 0.52 mm., stylets 0.10 mm., antennæ 0.85 mm., last joint of antennæ 0.05 mm., longest caudal seta 0.55 mm., inner seta 0.30 mm.

The corresponding measurements of *C. coronatus* are the following: Total length 1.66 mm., first segment 0.67 mm., entire thorax 1.12 mm., abdomen 0.54 mm., stylets 0.07 mm., longest seta 0.6 mm., inner seta 0.3 mm., antennæ 0.95 mm.

As very strong evidence of our observation of the occurrence of sexual adults with larval characters may be noted a statement of Schmeil himself, who nevertheless seems to be so given to his theory as to be quite unable to see its bearing. He says: "Nicht unerwähnt soll bleiben, dass zwischen den exemplaren dieser art, welche den Tümpeln des Brockengipfels entstammten, sich eine Anzahl Männchen vorfanden, bei welchen sämtliche Aeste der Schwimmfüsse aus je drei Segmenten bestanden. Dieser Fall ist desshalb besonders interessant, weil hier ein Fortschreiten nach Vervollkommnung im Körperbau eines Tieres direct zu konstantiren ist." The writer is obliged to confess that he cannot understand why it is not more natural to regard the two-jointed condition (which is common to all larvæ) as a retarded or atavistic state, from which the species tends to escape toward the norm under favorable condition, than to postulate an exceptional specific norm (which in this case is confessedly unstable), and assume that from some cause, utterly unknown to us, the form tends to "proceed to a greater completeness in structure." The "greater completion" or realizing of its ideal—"Vervollkommnung"—implies that it is incomplete or has failed to attain its specific possibilities, unless, indeed, the generic characters have for Schmeil a sort of metaphysical cogency or power over its members apart from its heredity. The same considerations apply to the antennæ. The fifth feet are as in *C. bicuspidatus*. The form of the receptaculum is much relied on to differentiate this form, but is admitted to vary within wide limits. Length 0.86 to 1.1 mm. Motions slow.

* **Cyclops modestus** Herrick.

PLATE XXI, FIGS. 1-5.

Herrick '83 and '84; Marsh '92.

This small species, 1.0 mm. long, was first recognized in Cullman county, Ala., but occurs also in our lakes. The color varies, but very characteristic is the peculiar shining or glaucous surface of the strongly arched thoracic shield and the evenly curved segments of the abdomen. The antennæ reach but little beyond the very long first segment; they are usually 16 jointed, but I have notes of a similar form in which the antennæ are 17-jointed. The feet are all three-jointed and armed as follows:

FIRST FOOT.

Outer ramus	ex.	3 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	2 spines, 1 seta.
	in.	3 setæ.		in.	2 setæ.

SECOND FOOT.

Outer ramus	ex.	3 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	4 setæ.		in.	1 spine, 2 setæ.

THIRD FOOT.

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	4 setæ.		in.	1 spine, 2 setæ.

FOURTH FOOT.

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	4 setæ.		in.	2 setæ.

The fifth foot is obscurely three-jointed, the second joint bearing a short spine and the terminal joint two spines of varying length. The caudal stylets are once and a half as long as the last segment, and are peculiarly excavated for more than the caudal one third, beginning at the point where the lateral spine is situated. The outer apical seta is short, the median setæ are rather short while the inner seta is nearly as long as the outer median. All these setæ are pectinate. The receptaculum seminis is elongate oval. The antenna of the male is divisible into five regions, the third being formed by the thickening and union of four or more segments. Color violet or purplish red.

* **Cyclops capilliferus** Forbes.

PLATES VI, FIG. 13; XXVIII, FIGS. 1-4.

Forbes '93.

This is a symmetrical, compact *Cyclops*, with the cephalothorax closely articulated, widest in the middle, and the sides regularly convex, with the abdomen narrow and slender, with three well developed caudal setæ, and 16 jointed antennæ bearing several very long setæ.

The abdomen, with caudal furca, is contained a little less than twice in the cephalothorax, and the breadth of the latter is just half its length. First segment very long, five times the length of the second; second and third equal; the fourth very short, on the median line semicircularly excavate behind. The abdominal segments in the female diminish regularly in length from first to last. The caudal rami are twice the length of the last segment and one fourth as broad as long. The lateral seta is placed a trifle beyond the middle of the ramus; the outer terminal seta is a short, naked spine; the other three well developed and plumose. The inner and outer of these are of nearly equal length, the latter a little longer, the middle one much the longest one of the group. Antenna moderate, reaching about to the middle of the second segment of the cephalothorax. Sixteen-jointed in all adult females, and further especially distinguished by the presence of very long flexible setæ upon the first, third, tenth and fourteenth segments. Terminal setæ likewise very long. The seta borne by the first segment extends to the twelfth; that of the third reaches to the fourteenth; that upon the tenth segment extends to the

tip of the antenna, and that upon the fourteenth far beyond it. The first segment is as long as the two following, and very nearly twice as long as wide. The second is very short, its length one-fourth its width, and the length and width of the third are equal Of the three terminal segments the penultimate is longest, being twice as long as broad; the antepenult two-thirds the length of the following; the last is about as wide as long. The armature of the legs is as follows:

First Feet.

Outer ramus	ex.	2 spines.	Inner ramus	ex. 2 setæ.
	ap.	1 spine, 2 setæ.		ap. 2 setæ.
	in.	3 setæ.		in. 1 seta.

Second Feet.

Outer ramus	ex.	2 spines.	Inner ramus	ex. 3 setæ.
	ap.	1 spine, 2 setæ.		ap. 2 setæ.
	in.	4 setæ.		in. 1 seta.

Third Feet.

Outer ramus	ex.	2 spines.	Inner ramus	ex. 1 seta.
	ap.	2 setæ.		ap. 2 setæ.
	in.	4 setæ.		in. 3 setæ.

Fourth Feet.

Outer ramus	ex.	2 spines.	Inner ramus	ex. 1 seta.
	ap.	2 setæ.		ap. 2 setæ.
	in.	4 setæ.		in. 2 setæ.

The fifth feet are two jointed, the terminal joint with one long and one short seta at tip: the basal joint with one long seta without. Length without setæ 1.2 mm. Grebe lake, Yellowstone Park.

*Cyclops insignis Claus.

Plates XXII, Figs. 11-14; XXIII. Figs. 6, 7.

Claus '57 and '63; Sars '63; Fric '72; Brady '68 (lubbockii) and '78 and '91; Rehberg '80; Herrick '84; Richard '91; Schmeil '91 and '92.

Schmeil has doubtfully identified *C. lubbockii* Brady with the brackish varieties of *C. bicuspidatus* = *C. helgolandicus* Rehberg. Though the names are given in the synonomy above, it is with the understanding that they at least constitute a distinct variety.

The typical form has an elliptical cephalothorax, the first segment being more than half as long as the remainder. The abdomen is relatively short and its first segment greatly expanded. The stylets are very long, fully half as long as the rest of the abdomen, and are longitudinally ridged as in *C. strenuus*. The lateral apical setæ are short, while the median ones are long and more nearly equal than usual. Antennæ 14-jointed, not much longer than the first segment of thorax, similar to *C. strenuus*. Fifth foot exactly as in *C. strenuus*. Length 2.5 to 5.0 mm.

In the previous edition it was suggested that this is but an atavistic form of *C. pulchellus* = *C. strenuus*, and although Schmeil does not accept this suggestion, he adds strong probability to it by noticing that the eighth joint of the antennæ show indications of subdivision and have the armature requisite to correspond with *C. strenuus* after such division. Against the suggestion he urges, (1) that this form is not simply found in scattered individuals but in large groups; (2) that there seems no sufficient reason for such suppression; (3) that the animal is often very large, and we should therefore expect it to attain its full development. To these it must be replied (1) that it is very common for *Copepods* of a given stage to be associated almost to the exclusion of others, thus the net will sometimes bring in from a given locality almost solely half grown *Diaptomi* where on a previous visit adults preponderated; (2) that we know too little of the biology of these animals to plead our ignorance as a reason for rejecting what is anatomically probable; (3) rapid increase in size (unusually rank nutrition) may be just a condition for retardation of development, as it often is in other groups of crustacea. Questions of this nature demand careful and continuous observation and experiment, and should not be arbitrarily closed by *a priori* arguments.

Respecting *C. lubbockii* Brady, whether it should be considered an atavistic form of *C. strenuus* or of *C. bicuspidatus* is difficult to say. Its brackish habitat speaks strongly in favor of its not being a distinct or permanent species. The short first thoracic segment and antennæ incline me to ally it to the latter species. Specimens sent me by Mr. E. A. Congdon of Columbia College, from Long Island, seemed identical with *C. lubbockii* Brady, and if this form cannot be brought into relation to a 17-jointed species, Brady's earlier name should be revived. It must be observed, however, that the American specimens were within direct influence of the sea.

*Cyclops serrulatus Fischer.

PLATES XV, FIGS. 8-11; XIX, 2-5; XXVI, FIG. 10; XXIX, FIGS, 17-19.

Fischer '51; Lilljeborg '53; Claus '57 and '63; Sars '63; Lubbock '63; Heller '70; Fric '72; Hoek '78; Brady '78 (serrulatus var. montanus, and serrulatus); Uljanin '75; Herrick '82, and '84 (serrulatus var. elegans, and serrulatus); Rehberg '80 (agilis); Cragin '83 (pectinifer); Daday '85[5] (agilis); Sostaric '88 (agilis); Thallwitz '90 (agilis); Lande '90 (agilis); Richard '91; Schmeil '91 and '92; Marsh '92; Turner '92.

The commonest and most abundant species of the Eastern States.

Cephalothorax oval, compact. Abdomen slender and about three-fourths as long as the thorax, cylindrical, suddenly enlarged before its union with the thorax. Antennæ slender, reaching nearly to the

cephalic margin of the last thoracic segment, tending to assume during life the form of a rude Z, the proximal four joints forming the base; the last three joints are slender and elongate and are each armed with a hyaline plate. Antennules small, reaching about the sixth joint of the antennæ. Jaws small, with large teeth. Caudal stylets over four times as long as wide, nearly as long as the last two abdominal segments, serrate down the outer margin. Outer apical seta changed to a very strong and serrate spine, inner seta weak, outer median seta over two-thirds as long as the inner. Formula for the armature of the feet as follows:

First Feet.

Outer ramus	ex.	3 spines.	Inner ramus	ex.	1 seta.
	ap.	2 setæ.		ap.	1 spine, 1 seta.
	in.	3 setæ.		in.	3 setæ.

Second and Third Feet.

Outer ramus	ex.	3 spines.	Inner ramus	ex.	1 spine.
	ap.	1 spine, 1 seta.		ap.	1 spine, 1 seta.
	in.	4 setæ.		in.	3 setæ.

Fourth Foot.

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	4 setæ.		in.	2 setæ.

The spines of the feet are strongly serrate and the setæ fully pectinate. The fifth foot is one-jointed, having one very strong serrated spine, an apical seta and a longer inner seta. The adjacent margins of the fifth segment are serrate. Egg sacs oval, as long as the abdomen, divaricate. Eggs few, dark. Length inclusive of stylets 1.5 mm., thorax 0.62 mm., first segment 0.32 mm., abdomen 0.42 mm., stylets 0.11 mm., longest seta 5.0 mm., antennæ 0.5 mm. Color rather opaque. A pelagic form or variety has been distinguished, but it must not be confused with var. *montanus* of Brady.

* **Cyclops serrulatus** var. **elegans** Herrick.

Distingnished from the type by the greater size, and the elongation of antennæ and caudal stylets. We will first of all give the measurements which afford a criterion for judging of the form and proportions.

Total length 1.34 mm., thorax 0.76 mm., abdomen 0.40 mm., stylets 0.18 mm., greatest width 0.42 mm., inner median caudal seta 0.60 mm., outer median seta 0.36 mm., inner seta 0.08 mm. The first segment of the thorax is long proportionally (0.40 mm.). The antennæ are very long, reaching beyond the base of the third segment (0.68 mm.). The egg-sacs are elongate-oval, being more slender even than in typical *C. serrulatus;* in the animal measured they were 0.50 mm. long by 0.19 mm. wide. The caudal stylets are slightly longer than the last two segments of the abdomen. The antennules are very short, and

each joint has its series of fine teeth. The free lower margins of the thorax are ornamented with series of prominences, while the last segment is extended into a blunt angle bearing long teeth. The last segment of the abdomen is spiny-margined and is ornamented with a double row of spines at the anus. The armature of the stylets as well as that of the feet is identical with that in typical *C. serrulatus*. The last two joints of the antennæ measure 0.1 mm. each, while the two previous measure unitedly 0.12 mm. The color is not opaque as in the smaller form usually. Brady's var. *montanus* has shorter stylets than the type, but seems nearest the small dark form found in peaty waters in America. *Cyclops pectinifer* Cragin has no distinctive points, it being typical *C. serrulatus*.

Marsh also finds this variety rarely elsewhere than in pelagic localities, and only in occasional association with the type. Schmeil notes discrepancies in the original measurements of the two forms, and is led to doubt their distinctness. It can only be replied that the distinctions insisted on do actually exist, and are very apparent when the forms are before one, and are sufficiently obvious from the measurements given above.

Cyclops macrurus Sars.

Sars '63; Uljanin '74 (alajensis); Brady '78; Rehberg '80; Sostaric '80; Herrick '84; Vosseler '89; Lande '90; Richard '91; Schmeil '91 and '92.

This form is so close to *C. serrulatus* as to suggest the question whether it is more than a well-marked variety. From that species it differs in the shorter antennæ which are hardly longer than the first segment, the slender, smooth abdomen, and the greatly elongated stylets, which lack the lateral line of teeth. The feet and the proportional length of the joints of the antennæ are as in *serrulatus*. The species occurs in Scandinavia and Germany, but rarely.

Cyclops prasinus Fischer.

Jurine '20; Fischer '60; Vernet '71 (longicornis); Vosseler '86 (pentagonus); Richard '87 (pentagonus var. vichyensis) and '91 (pentagonus); Schmeil '91 (pentagonus) and '92.

Cephalothorax broad, attenuated behind. Abdomen slender, nearly cylindrical. Stylets one and one-half as long as last abdominal segment. Lateral seta a little distad of the middle. Outer apical seta forming a strong spine and about as long as the inner slender seta. Longest seta four times the length of the stylet, shorter median seta three-fourths as long. Antenna reaching the end of third thoracic segment, proportions and armature as in *C. serrulatus*. Fifth foot one-jointed, closely resembling that of *C. serrulatus*, but the external seta is delicate and not a strong, heavy spine. Ova few, appressed. Length 0.8 to 0.9 mm. Color green.

* Cyclops fluviatilis Herrick.

PLATES XXVI, FIGS. 1-8; XXX, FIG. 1.

Herrick '82, '84 and '87; Cragin '83 (magnoctavus); Brady '91 (magnoctavus); Turner '92; Marsh '93.

This small species, first described in America, has been encountered by Brady in Great Britain, though he chooses to make the comparison to *Calanidæ* of the original description a reason for adopting a subsequent name. It is one of the most abundant forms in many of our lakes and their outlets. In its smaller age form it is barely visible to the eye, while the larger and particularly the highly colored condition is conspicuous especially by reason of its rapid motions. In appearance it reminds one of *Cyclopsina gracilis*.

The body is slender, the cephalothorax being elongate, oval, with its first segment very long. In a specimen measuring 0.57 mm. to the end of the stylets, the following proportions were noted: First segment of thorax 0.22 mm., second and third segments each 0.056, fourth 0.032, total length of abdomen 0.17, stylets 0.032, longest seta 0.128, outer median 0.10 mm. The antennæ are nearly as long as the whole thorax, and are remarkable for the elongation of the seventh to ninth segments. There are elongated setæ upon the first and fourth segments. The last joint of the antennæ is slightly curved and carried at an angle to its predecessor during life, giving it the appearance of being hinged. It has also the rudiment of a knife ridge. The antennules are slender and elongate. The labrum has about twelve small teeth. The maxillæ have the usual form. The feet are peculiar in the exceedingly long setæ. The armature of the apical segments is as follows:

FIRST FOOT.

Outer ramus	ex.	3 spines.	Inner ramus	ex. 1 seta.
	ap.	2 setæ.		ap. 2 setæ.
	in.	3 setæ.		in. 3 setæ.

SECOND AND THIRD FEET.

Outer ramus	ex.	3 spines.	Inner ramus	ex. 1 seta.
	ap.	1 spine, 1 seta.		ap. 2 setæ.
	in.	4 setæ.		in. 3 setæ.

FOURTH FOOT.

Outer ramus	ex.	2 spines.	Inner ramus	ex. 1 seta.
	ap.	1 spine, 1 seta.		ap 1 spine, 1 seta.
	in.	4 setæ.		in. 2 setæ.

The fifth foot is small, one-jointed, and bears three small setæ. The abdomen is slender, though rather short. The stylets are three times as long as broad. The outer of the terminal setæ is a short spine, shorter than the stylet. The egg-sacs are appressed and contain four or five ova in the first state and a few more in the adult. The two

dimorphic states are very distinct and seem, in part at least, to be governed by habitat. The colors are frequently brilliant, varying from deep indigo to greenish brown. The coloring matter is somewhat irregularly distributed but is most persistent between the bases of the feet, in the last segment of the abdomen and in the last joints of the antennæ.

The full-grown female measures about 0.70 mm., the males being more slender. Oviferous females often have the fourth pair of feet with two-jointed rami. American authors find the species pelagic, and Brady, though he found it in ditches immediately connected with large sheets of water.

Marsh notes that there is a resemblance between this species and *C. pentagonus* Vosseler.

Cyclops capillatus Sars.

"Cephalothorax sub-ovate; anteriorly uniformly rounded; segments projecting somewhat laterally, the last being scarcely wider than the first abdominal segment. Abdomen attenuated posteriorly; caudal rami almost as long as the last three abdominal segments, hardly divergent; the external and internal apical setæ short and nearly equal, the interior of the median setæ as long as the abdomen, lateral seta about in the middle of the stylet. Antennæ of the first pair robust, slightly exceeding the first segment of the body when reflexed, with the twelve joints densely covered with long and divergent hairs. The last joint of the outer rami of swimming feet are elongated and armed externally with three spines, internally with four setæ; the interior apical spine of the interior rami of the fourth pair of feet longer than the exterior. Feet of the fifth pair large, with a large and thick basal segment and a small oval second joint bearing one long seta and a short spine. Ovisacs small, narrow and divergent. Eye very small. Length nearly 2.0 mm."

Very close to *C. viridis* in many points. Found only in Scandinavia.

Cyclops crassicaudis Sars.

Cephalothorax elongate-ovate; segments produced laterally, especially the last, which extends into a somewhat procurved process. Abdomen short and thick, first segment somewhat excavated; caudal rami equaling the last two segments of the abdomen. External apical seta longer than the internal, both short; median setæ long. Antennæ of the first pair 12-jointed, scarcely longer than the first segment. Swimming feet short and thick, spines and setæ short; the interior apical spine of the last joint of the inner ramus of the fourth

foot almost twice as long as the exterior spine. Terminal joint of the fifth foot small, armed with a spine and a seta; seta of the basal segment short. Ovisacs oval, somewhat divergent. Length 0.75 mm.

Found only in Scandinavia.

* Cyclops varicans Sars.

PLATES XIX, FIGS. 12 AND 13; XXX, FIGS. 2-8.

Sars '63; Uljanin '75 (orientalis); Lande '90; Schmeil '91 and 92.

The American form which approaches nearest to this species differs from it apparently in proportions. Unhappily we have only gathered the species once and our information depends on the camera drawings taken at that time. Rather slender, especially the abdomen which is nearly as long as the cephalothorax. First abdominal segment very long, as long as the rest of the abdomen. Stylets over twice as long as wide, lateral spine one third from the apex, outer lateral spine shorter than inner seta, median setæ rather long, outer two-thirds as long as inner, inner three-fourths as long as abdomen. Antennæ shorter than the first thoracic segment, 12-jointed, formula $-\breve{-}\breve{\smile}-\breve{-}\breve{\smile}\breve{-}-\breve{-}\breve{-}-$, setæ of moderate length. Feet with the following formula:

FIRST FEET.

Outer ramus	ex.	3 spines.	Inner ramus	ex.	1 seta.
	ap.	2 setæ.		ap.	1 spine, 1 seta.
	in.	3 setæ.		in.	3 setæ.

FOURTH FOOT.

Outer ramus	ex.	3 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	1 spine, 1 seta.
	in.	4 setæ.		in.	4 setæ.

Respecting the fourth foot it is plain that the last joint is homologous to two fused segments, and that the separation might take place at the next moult.

Fifth foot as in *C. bicolor*, but the basal segment more distinct, apical segment long, cylindrical and bearing a long seta. In the form of the stylets and antennæ this species corresponds to Schmeil's figures, but the first segment of the thorax is shorter and the abdomen is more slender. The specimen from which our outline was taken was extended by pressure, while that figured by Schmeil may be a little fore-shortened. We must leave to later study the settlement of the question, as also that of the relation between this and the next. Length 0.8 mm.; abdomen 0.35 mm., stylet 0.05 mm., longest seta 0.28 mm., antennæ 0.23.

Cyclops gracilis Lilljeborg.

PLATE XIX, FIGS. 10, 11.

Lilljeborg '53; Schmeil '91 (diaphanus), and '92.

Apparently this is a distinct species, characterized by the slender form, especially of the abdomen, which is to the thorax as 5 : 7, divergent cylindrical stylets, short setæ and form of the fifth foot and receptaculum. The antennæ are slender, reaching the caudal border of the fourth segment, and are of the form of the 12 jointed species; formula – ⏑ – ⏑ ⏑ ⏓ – – ⏓ ⏓ ⏓. Fifth foot with a broad basal segment and a cylindrical terminal one, which bears a short spine and a long seta. Eggs few. Feet all two jointed. Schmeil speaks of the fifth foot as one-jointed, but the fact that the basal segment is immovably soldered to the body should not prevent us from recognizing its existence. This species has been found only in Sweden, Poland and Germany.

Cyclops diaphanus Fischer.

PLATE XIX, FIGS. 6-9.

Fischer '53; Claus '63 (minutus); Heller '63 (minutus); Daday '85[5] (frivaldszkyi); Sostaric '88; Schmeil '92.

The above synonomy is derived from Schmeil's monograph, which can hardly be considered very authoritative since its author never saw the species and offers only comparative data to discriminate this species from the last. Abdomen broader than *C. bicolor*, stylets as long as the two preceding segments, lateral seta nearer the base than the end. The lateral apical setæ short, equal, median setæ as 2 : 3. Antennæ 11-jointed, short, only reaching the second segment. Swimming feet with two-jointed rami. Fifth foot with a short spine and long seta at the end of the cylindrical apical joint.

* **Cyclops affinis** Sars

PLATE XXX, FIGS. 9-11.

Sars '63; Uljanin '75; Brady '78; Rehberg '80 (pygmæus); Daday '85[5] (pygmæus, and affinis); Herrick '84; Vosseler '86; Lande '90; Richard '91; Brady '91; Schmeil '91 and '92.

Schmeil makes the statement that "Herrick regards *C. affinis* as 'var. b.' of *C. phaleratus* Koch, and identifies it with his *C. adolescens*," overlooking the plain statement that "it is impossible to sufficiently identify it [the American form] with any of the above," and the fact that Sars' description was appended in a separate rubric. Schmeil devotes considerable time to the relations of *C. adolescens* and is not unnaturally provoked by the inconsistencies in the two references, which are explained, however, by two provoking typographical errors

which were both beyond the writer's control. The first was the displacement of a line in the tabulated list of species in the Alabama crustacea, by means of which the figure of *C. phaleratus* was referred to *C. fimbriatus* and the error then repeated in the making up of the description of plates; second, in the Final Report, Plate 24, in Fig. 15 the printer has set *C. adolescens* one line too soon, making the figure of the receptaculum of *C. parcus* refer to the former species. Upon this point Schmeil remarks, "Schon hieraus ergiebt sich * * * mit welcher sorgfalt Herrick die Zeichnung angefertigt hat!" We beg that author to transfer his irritation to the typo, and believe that the drawing in question is substantially correct!‡ As to the position of *C. adolescens*, more beyond.

The original description of *Cyclops affinis* Sars is here repeated, and it justifies the doubt which, in the absence of authentic specimens or figures, was felt respecting its position.

"Antecedenti [C. phalerato] simillimus. Corpus autem minus robustum colore cœruleo vel potius glauco sat saturato insigne. Segmentum ultimum thoracicum ad marginem posteriorem extrosum pilis vel spinulis subtilissimis pectenatim exornatum. Rami caudales quam in C. phalerato aliquanto longiores, setarum apicalium interna quam externa multo breviore, intermediarum interiore altera fere triplo longiore longitudinemque abdominis superante, in medio aculeata dein vero subtile ciliata. Antennæ 1-mi paris segmento 1-mo corporis multo breviores, tenues, articulis 11 compositæ. Pedes 5-ti paris distincti, uniarticulati, setis 3, quarum interior ceteris multo major et ciliata, instructi. Sacci oviferi parvi abdomini appressi. Longit. circit. $\frac{3}{4}$ mm."

From *C. phaleratus*, which it closely resembles, it differs, according to Schmeil, in its more slender form, short stylets with single oblique series of spines, peculiar shape of the fifth foot and the method of motion and also especially in the number and relative length of the antennal joints and the form of this organ in the male.

The formula for the length of the antennal joints in *C. affinis* is – ⏓ ⏑ – ⏓ ⏑ ⏓ – – – –, while that of *C. phaleratus* is – ⏑ – ⏑ ⏑ – ⏑ ⏑ – –. The fifth foot is one-jointed, and this joint is quadrate with three spines apically. The stylets are twice as long as broad and are ornamented by an oblique line of small spines. The receptaculum is smilar in form to that cf *C. phaleratus*. The motion is a creeping or slow swimming near the surface. Length 0.85 mm.

* **Cyclops bicolor** Sars.

PLATES XVIII, FIGS. 3-3e; XXI, FIG. 12.

Sars '63; Rehberg '80 (diaphanus); Herrick '84 and '87 (diaphanus); Daday '85[5] (diaphanus); Lande '88 (diaphanus); Richard '91 (diaphanus); Schmeil '91; Marsh '92.

DESCRIPTION OF THE FEMALE: The body, not including the caudal setæ, measures from 0.65 to 0.80 mm. The following are measure-

‡Very curiously in Schmeil's reference to figures, p. 157, *C. fimbriatus* is referred to as *C. affinis*, Fig. 8, Plate VII.

ments of a rather small specimen: First segment of cephalothorax 0.24, second segment 0.068, third segment 0.06, fourth segment 0.036 mm.; the remainder of the body to the stylets measures 0.24 mm., while the stylets themselves are 0.024 mm. long and bear a lateral spine about one-third their length from the apex. The longest seta is 0.24 mm. long, the outer median seta being about 0.19 mm. The body is comparatively rather slender and tapering, with an unusually long first thoracic segment. (Measurements of a large specimen of this species may serve to indicate the observed fluctuation in size: Length 0.81 mm., thorax 0.50, abdomen 0.31, stylets 0.06, longest seta 0.40, outer median seta 0.36 mm.) The antennæ are considerably shorter than the first thoracic segment, being about 0.19 mm. long, the seventh and eighth joints about equal and the longest of the eleven segments. The first joint is very large. The antennæ in a state of rest assume a curved position. The antennules are small, the terminal segment measuring (in the animal first above referred to) 0.032 mm. The labrum has six similar teeth, which are bordered on either side by a larger one. The longest joint of the outer maxilliped measures 0.06 mm. All the feet are usually two-jointed in both rami. The outer ramus of the first pair of feet has the terminal joint armed externally with three stout spines, terminally with two setæ, and internally with three setæ. The second and third pairs of feet are alike in their spinous armature, the outer side of the terminal segment bearing three spines, the end a very large toothed spine and a seta, and the inside four setæ. The fourth foot has two spines on the outside of the terminal joint, a heavy spine and a seta terminally, and four setæ within, while the terminal joint of the inner ramus bears externally one spine, apically two spines, and internally three setæ. The fifth foot consists of a fleshy basal segment, more or less coalescent with the last thoracic segment and bearing a curved spine externally, and a terete terminal segment 0.012 mm. long, which has an apical seta four times its own length. The abdomen is slender and its last segment bears a series of spines dorsally on the caudal margin. The egg-sacs are appressed and contain eight to twenty rather large ova. The color is bronzy and opaque.

Although Marsh says his "specimens agree very well with the descriptions of Sars and Schmeil, the only marked difference being in the length of the caudal setæ," we find several points of divergence which may make it necessary to create a new variety or species. The stylets are much shorter in the American form and the setæ are longer. The external apical seta is a well formed spine. The form of the basal segment of the fifth foot is more as in *C. caricans*, there being a decided protuberance to receive the second joint. The receptacu

lum is also more elongate, but this is subject to considerable variation.

The armature of the feet, structure of antennæ and most diagnostic points agree so fully that I hesitate to separate the two forms. In the description of *C. diaphanus* given in the first edition some of the statements apply to *C. varicans* or an allied form. The form of the receptaculum figured on Plate R, Fig. 12, of that report may be compared with that of Plate VII, Fig. 3[e], Crustacea of Alabama, to illustrate the range of variation.

* Cyclops phaleratus Koch.

PLATES XVII, FIGS. 1-7; XVIII, FIGS. 2-2[d]; XIX FIG. 1; XXI, FIGS. 6-10.

Koch '35; Fischer '51 (canthocarpoides); Lilljeborg '53 (canthocarpoides); Claus '57 and '63 (canthocarpoides); Lubbock '63 (canthocarpoides); Sars '63; Fric '72 (canthocarpoides); Poggenpol '74 (lascious); Uljanin '75; Brady '78 and '91; Herrick '82 (adolescens), and '84 and '87; Cragin '83 (perarmatus); Daday '85[5]; Richard '91; Schmeil '91 and '92; Turner '92; Marsh '93.

Body sub-cylindrical, thorax little enlarged for the genus, abdomen large and cylindrical. The transition from thorax to abdomen is less sharply marked than usual. Cephalothorax oval, first segment longer than the remainder. Abdomen shorter than thorax, stylets short and profusely spinous. An oblique row of spines passes across the stylet some distance behind the lateral spine, which is very short, and other rows of spines or teeth may ornament the inner aspect or may be absent. The whole inner aspect is also ciliate. The outer apical seta is a ciliate or toothed spine and the inner is shorter and weaker. The outer median seta is nearly as long as the abdomen and is sparsely clothed with sharp teeth. The inner median seta is about half as long and similarly ornamented. The antenna is usually 10 jointed but frequently is 11-jointed, (?) and is much shorter than the first thoracic segment. The swimming feet all have three-jointed rami and are strongly armed with closely set short teeth. The armature of the terminal joints of the fourth foot is as follows:

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	4 setæ.		in.	2 setæ.

Egg-sacs appressed, closely filled with many ova. I here append the original description of *Cyclops adolescens* Herrick (=*C. perarmatus* Cragin) for comparison with the description of *C. affinis* as transcribed below, as it contains other data: "Thorax oval, broad, acute anteriorly; last segment large and separated by a constriction from the anterior ones. The head is beaked below; first thoracic segment large and long (0.36 mm.): last thoracic segment wide, united closely with the first abdominal segment, armed with series of teeth. Abdomen

short, especially the last segment, with is toothed behind; stylets very short. The antennæ are much shorter than the first segment, 11-jointed. The maxillipeds are very small. All the feet are armed with a row of very large teeth or lanceolate spines down one side: fifth foot one-jointed, with three spines, the outer being smooth, the others spiny; egg-sacs variable, narrow, appressed; eggs large, color usually dark. The animal moves like *Canthocamptus*, and is able to progress out of water better than other species. The following measurements will give an idea of the proportions: Length 1.26 mm., thorax 0.76 mm., abdomen 0.44 mm., stylets 0.06 mm., longest seta 0.34 mm., antennæ 0 28 mm., width of thorax 0.44 mm."

Measurements of another specimen are as follows: Length 1.1 mm., thorax 0.65, first segment 0.33, abdomen 0.45, longest seta 0.6.

The male is more slender (0.93 mm. long) and the longest caudal seta greatly exceeds in length the whole abdomen. The antennæ are strongly modified.

*Cyclops fimbriatus Fischer.

PLATES XVII, FIGS. 8, 9; XXI, FIG. 11; XXV, FIGS 9-14.

Herrick '82 (crassicornis), and '84 and '87‡; Turner '92; Marsh '93. [The manuscript gave not the slightest hint as to date or reference in the following, given in the order of the manuscript:] Mueller (crassicornis); Fischer; Sars (crassicornis); Heller (gredleri); Fric (pauper); Uljanin (crassicornis); Brady (crassicornis, and fimbriatus); Rehberg (poppei, and fimbriatus); Daday (fimbriatus, and margoi); Vosseler; Schmeil; Richard.

A small species (0.8 to 0.9 mm.). Thorax oval, not greatly expanded, angles of segments rather prominent. First thoracic segment forming about half the length of the cephalothorax. Abdomen rather long and thick, terete, about as long as the thorax. Last two abdominal segments armed with a row of spines at the caudal margin. Caudal stylets twice as long as the last abdominal segment.

A series of small teeth in a longitudinal series generally ornaments the stylet. Lateral spine small. The outer apical spine strong, the two median setæ long, spinously armed, inner two-thirds as long as the outer. Inner apical seta weak and short, pectinate. Antennæ shorter than the first segment, 8-jointed; formula: $--\perp--\smile\smile\perp\perp$, the basal joint with a small semicircular series of fine bristles. Antennules short, apical segment short with but two strong setæ and several smaller ones. Feet armed with spines and bristles. Formulæ for fourth foot as follows:

Outer ramus	ex.	2 spines.	Inner ramus	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	4 setæ.		in.	2 setæ.

‡By a curious mistake in this paper on p. 14, the reference to Plate VII, Fig. 2, is placed opposite C. fimbriatus and not, as it should be, opposite C. phaleratus. This mistake was then reproduced in the description of plates, p. 56.

Fifth foot small, one-jointed, with three spines, of which the inner is large and serrate. Total length 0.8 mm., thorax 0.42 mm., abdomen 0.38 mm., stylet 0.09 mm., antenna 0.18 mm. Egg-sacs appressed, with few ova.

Cyclops aequoreus Fischer.

PLATE XXIII, FIG. 5.

Lilljeborg '53 (magniceps); Fischer '60; Brady '68, '78 and '91.

Body compressed, attenuated caudad. Antennæ shorter than first segment, stout, six jointed, fourth and sixth segments longest. Fifth feet with a small basal joint and a triangular lamina bearing on the distal margin three spines and a seta, lateral margins ciliate. Abdomen slender, first segment very long, last very short. Stylets less than twice as long as wide. Longest seta as long as the abdomen. First foot with the formula

Outer ramus	ex.	3 spines.	Inner ramus	ex.	1 spine.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	4 setæ.		in.	3 setæ.

Length 0.85 mm.

This species lives in salt marshes and brackish pools, and is interesting for its departure from the generic type in several particulars.

Three species of *Cyclops* were found by E. Pratz in 1866 in the hydrant water of Munich and described as new.

The first of these, *C. cæcus*, is blind and colorless and has 11-jointed antennæ.

The second species, *C. subterraneus*, is doubtfully identified by Schmeil with *C. bicuspidatus*.

The third, *Cyclops serratus*, is probably a form of *C. viridis* Jurine.

Two blind species of *Cyclops* have been described by G. Joseph ('82): *C. hyalinus* and *C. anophthalmus*, but the descriptions are not accessible to me.

HETEROGENESIS AND PREIMAGO FERTILITY IN CYCLOPS.

The present writer's views and statements in respect to the relation of sexual and anatomical maturity and the influence of the environment have given rise to a running criticism occupying many passages throughout the recent monograph of Schmeil, '92.

These criticisms are so inconsistent, and at times so contradictory of the author's own observations and statements, that it is hopeless to attempt to answer them, especially as his notions respecting varietal and specific relations seem strangely obscure. If a plain statement of the position of the present writer will remove any obscurity he feels bound to offer it.

First—As a matter of frequent observation and beyond all doubt, it frequently happens that a young female *Cyclops* becomes oviparous before the moult, when it acquires its full adult complement of segments in the antennæ and feet. Such animals are obviously larval and exhibit this fact in their small size, pale color, small number of eggs, imperfect development of serrations, spines, etc. Schmeil himself has observed males in this stage with spermatophores and had before him a figure in my Final Report (Plate Q, 5), reprinted from the tenth annual report, in which this matter is plainly stated, of young gravid females of *C. serrulatus*—a species not likely to be mistaken—with less than twelve joints in the antennæ and two-jointed rami of the swimming feet. After admitting that "kein Grund vorliegt, an der Richtigkeit der Herrick'schen Angabe zu zweifeln," he says "Herrick figures, as a matter of fact, not a young form but a completely developed animal, in which, to be sure, in certain segments of the antennæ the normal subdivision has not taken place." He adds (entirely misconceiving my position as to heterogeny): "Dass hier nicht an einem Fall von Pädogonie oder gar Heterogenie zu denken ist, ist selbstverständlich." Had he consulted the original paper Schmeil would have seen that the failure to develop a full complement of antennal joints is but one of the symptoms of the larval state manifested by this specimen. Moreover, such forms are found among vast numbers of adults and larvæ in the midst of the most prolific seasons and in suitable situations. We claim that the next moult would have brought to this very animal its normal adult structure. Nor is this an isolated case. Yet Schmeil could in all consistency be forced to erect a variety for such forms. In glaring inconsequence, we find, on p. 101, Schmeil says of *C. clausii* Heller: "Obgleich ich der Ansicht bin, dass wir es hier wohl kaum mit einer selbständigen Art, sondern nur mit einer Jugendform einer anderen (des *C. viridis*) zu thun haben," etc.

Second—As a second and entirely distinct point, though confused with the former by Schmeil, it is believed that many of our species, especially such as live in pools which undergo great changes with the season by reason of evaporation, intrusion of water plants or animal forms serving as food, etc., may, after reaching full maturity and bearing more than one generation of eggs, undergo considerable changes, or that, under these changed conditions, what is usually the ultimate condition becomes a transitory one. This change may show itself not only in increased size but in enormous enlargement of the setæ. For example, I have seen *C. ingens* with the pectinating hairs on the setæ elongated till they became long hairs. All the spines and plates and serrations are exaggerated, while the relative proportions are altered.

In the case of *C. viridis* this is especially liable to occur, because of its stagnant stations. The color changes with the rest and the change

may be noticed in the same pool during the progress of the seasons. In these cases, according to our nomenclature, the modified form is a post imago, and if young born from the ordinary female enter this state and produce young in turn which never reach that state, we have a case of what was termed "heterogenesis" in the old general sense; i. e., two cycles of development occur in the same species. Now, as these cycles are dependent on environment, the process may be termed pædogony if the term is taken in the sense indicated. What to do with such cases is puzzling to taxonomy. It is obvious that they are quite different from the sporadic appearance of sexually functional larvæ, for here we have a stage which does not necessarily belong in the history of the species, and is, as it were, superinduced. The objection raised by Schmeil against making varieties of them—i. e., that you cannot fix an arbitrary size limit—would militate against almost all geographical varieties equally. In fact, however, the changes following the last moult are usually evident enough to produce no trouble. In the case of *Cyclops signatus* we are confronted by a question of fact. This is undoubtedly the most conspicuous instance, if an instance at all, of the change referred to. If the actual rearing of *C. signatus* var. *coronatus* should prove that *C. signatus* var. *tenuicornis* does not belong in its cycle then the two forms must be separated and this particular instance of pædogony disappears. We think it possible, however, to prove the contrary. Most remarkable of the many curious statements made by Schmeil on this point is the following: "Herrick even in his later work is not in position to demonstrate among the known species a single sexually mature larva. He is not in the position to bring a proof of a single one of his assertions. Also none of the other investigators has observed this, according to Herrick, common phenomenon." Having overlooked my earlier paper he is surprised at the failure to again revert to it. But, after his own admissions, how he can deny the evidence of sexually mature larvæ is unintelligible.

FAMILY HARPACTICIDÆ.

Numerically the largest of the families of the *Copepoda*, this group contains predominatingly marine and mostly minute animals, frequently of strange and grotesque form. A few of the marine forms, inhabiting the Gulf of Mexico, are figured in the report of the Minnesota Academy of Sciences for 1881. Of the over thirty genera of the family less than a half dozen are not exclusively marine, and of these most are brackish-water residents. The genus *Bradya* contains blind *Copepodæ* living in slime.

The name was proposed by Dana, but was dropped in the final report. Again revived by Claus, it is now in use by the best authors.

The general form and structure closely resembles that of the *Cyclopidæ*. The following characters are the more important ones in distinguishing the family from the other families of the order:

Body flattened or sub-cylindrical. Abdomen usually not much smaller than the thorax, from which it is not separated by a sudden constriction; antennæ rather short, 4- to 10-jointed; mandibles strongly toothed, palpate; maxillæ well developed, palpate; first pair of maxillipeds with strong teeth at the end, second pair usually forming a claw. The first pair of feet are often turned forward or prehensile; fifth pair one- or two jointed, serving as egg supports in the female.

Most species live among sub-aquatic vegetation.

THE SUB-FAMILY CANTHOCAMPTINÆ,

To which our sole genus belongs, is further distinguished from the other sub-families of *Harpacticidæ* by the fact that the second maxilliped has a prehensile hook. The feet of the first pair are not clawed, but have the inner branch elongated, and the palp of the mandible is one-branched.

GENUS CANTHOCAMPTUS Westwood.

These little animals may be secured in considerable numbers by gathering a supply of water from among weeds in shallow ponds and permitting the debris to settle in a spot where light only touches the jar from one side, when the *Canthocampti* congregate on the exposed side.

Canthocamptus is an elongated animal, with the body divided rather obscurely into two portions, of which the first, or anterior portion, is largest. This part of the body has five segments, each of which has at least one pair of appendages. The first, consisting of the head proper with one of the somites of the body or thorax, as is discovered by observing that a pair of legs is attached to it, is the largest segment of the body.

As seen from above, it is triangular and extends in front into a short, stout beak or snout, like the rostrum of a crayfish. Above the beak, in the centre of the forehead, is the eye, consisting of pigment and two lenses, showing that we really have to do with two eyes confluent on the median line. This is the simplest form of a compound eye. The same method of compounding the eyes is exhibited in a more complicated manner by *Daphnia* and other *Cladocera*. On either side of the beak springs an antenna with six to nine joints of unequal size. The first three joints are profusely covered with hairs. The fourth joint is more slender than the preceding, and terminates in a process below, which bears besides a long hair a peculiar blunt

bristle that serves some unknown purpose—probably being sensory in function like the similar hairs on the antennæ of some *Cladocera*. The next joint is shorter than the rest, while the remaining three are spined at definite points. The antennæ of the male are curiously altered, or geniculate, on both sides, as in *Cyclops*. The three basal joints are shortened, while more or fewer of the following ones are coalescent, followed by a hinge joint and two elongated segments.

The second antennæ or antennules are two-jointed, and the basal joint has a two-jointed branch or palp; the terminal joint is covered with spines; at the end are longer and curved spines, jointed in the middle.

The mandible is a flattened plate with digitate teeth at the end, on one side of which springs a two-jointed palp, and from the other a blunt process. The maxilla is somewhat like it, but has rudiments of other elements.

The first pair of feet have two three-jointed rami. The outer ramus is shorter and with the longer branch is directed forward. The fourth foot has the inner branch two-jointed. The inner branch of the third foot of the male is peculiarly modified to form a prehensile organ, as it is this foot which fastens the spermatophore to the female. The fifth feet are composed of two flat plates.

The second division of the body, the abdomen, consists of five segments, of which, however, the first two are united in the female. The last segment of the abdomen bears two stylets, which are sometimes considered as together constituting an additional segment. Each of these stylets has, with several small spines, two elongated caudal setæ, one of which is usually as long or longer than the entire abdomen. The stylets are usually considerably longer than wide, but the proportions vary somewhat in different species.

Viscera: The body cavity is traversed by the alimentary canal, which is a straight tube with no lateral cæca or blind sacs, as in some other *Copepoda*. The canal is divided into four more or less distinct portions; the first section is a slender, muscular tube, extending from the mandibles nearly through the first segment, opening into the stomach proper, which is a muscular and glandular sac or tube, filling the greater part of the thorax; at the beginning of the abdomen, the sac is constricted and becomes the intestine proper; near the extremity again there is another change and the intestine loses its glandular character, and, by a peculiar adaptation becomes a sort of force-pump, which, during life, is constantly pumping water in and out, serving as a means of respiration. This anal respiration is quite common among aquatic animals in this as well as other orders. This latter section of the canal is the rectum, and opens beneath a toothed anal

plate, above and between the stylets. No special divarications or cæca are appended to the digestive tract, and the only other organ which is at all considered to belong to the alimentary system, is what is known as the "shell-gland," present in most crustacæ, but till recently thought to be absent in *Canthocamptus*. It is a coiled tube found in the lower part of the first segment of the thorax. It is impossble to find this organ in *Canthocamptus*, in every case, it being very obscure; and its office is uncertain, though it is supposed, perhaps with little reason, to be hepatic in function.

There is no functional heart in this animal, but its place is taken by a peculiar apparatus, hitherto undescribed; this consists of a tube, surrounding the posterior portion of the alimentary canal. This sac around a sac is open in front, and serves by a double mechanism the office of a pulsating heart, though in a very imperfect manner.

There are no true hæmatic or lymph corpuscles in this animal; so far, at least, none have been discovered. The place of these blood corpuscles is taken by globules of yellowish or red color of the most diverse size. These nutritive globules, or fat globules, as they have been called, are undoubtedly reservoirs of nutriment in a shape convenient for the animal's use, and equally certainly are derived from the contents of the intestine. In those *Copepoda* which have a functional heart, it is open anteriorly into a general body-cavity in the same way as in this animal. That a portion of the vascular system should surround the alimentary canal is no unexampled thing, for in *Daphnia* a large sinus embraces a portion of the canal. The same provision as this described in *Canthocamptus* occurs in the *Cyclopidæ*. The nutritive globules are often very large, and are frequently extremely abundant, especially in females soon to become gravid. Three-hundredths mm. is not a large measurement for the diameter of such drops.

The nervous system is very hard to trace, consisting of a large pear shaped ganglion just below the eye, from which extend commissures around the œsophagus, connecting them with the ventral ganglia lying between the bases of the feet. The senses are not apparently well developed, for, excepting the eyes, we cannot locate with certainty the organs of any sense. There are, however, two spots which are evidently devoted to special sense: first, the processes on the fourth joint of the antennæ, which may be simply the seats of tactile sense, or may have nerves suitable for perceiving chemical stimuli; second, the area on the forehead bordered by a raised line and covered with little pits, each with a small bristle. The character of this organ can be but conjectured; it may be homologized with the frontal nervous organs of the *Cladocera*.

The sexual organs are quite extensively developed, and periodically obscure the remaining viscera. In the male the simple testis is situated in the second segment, and the single vas deferens, after numerous windings through nearly the entire length of the body, opens at the base of the first abdominal segment under a spined plate. A part of the vas deferens is of a glandular character and secretes an elongate tube, the spermatophore, which serves to contain the spermatozoids, and is fastened by the male at the opening of the median pore of the female; on contact with the water this tube, which is at first soft, contracts and presses the contents into the opening of the female organs. So long is the vas deferens that as many as three spermatophores are sometimes seen in the body at once. The spermatozoids are very small. The geniculated male antennæ are used in grasping the setæ on the tail of the female, and the curiously modified inner branch of the third foot of the male may assist in fastening the spermatophore upon her body. The ovary occupies the same position as the testes, and the two ducts are coiled in the body from end to end, opening in the median pore behind the fifth pair of feet. When the eggs are ready to be laid, they are forced out, carrying with them a film of the secretion of the lower, glandular portion of the ducts, which is of a collodion-like consistency, and which forms the inclosing sac. The young become fully developed sexually before they assume their final form, and it is not unusul to find ova bearing females which are not only much smaller than the parent, but with considerable differences in the various organs.

This sort of heterogenesis is not uncommon among lower crustacea, for the young may differ much from the mother till after they have themselves produced young.

Four species have been recognized in America, of which one is certainly identical with a widely distributed European form, and a second is probably identical with an English species. *C. palustris* Brady seems to depart considerably from the norm of the genus and may prove a type of a marine genus. No true *Canthocamptus* is more than accidentally marine.

The ten species below enumerated are all that have fallen under the author's notice, though others may have been mentioned.

KEY TO THE GENUS CANTHOCAMPTUS.

I. Inner ramus of the fourth foot two-jointed.

a. Inner ramus of the first foot two-jointed.

* 1.0 mm. long; basal joint of fifth foot small. . . . . **gracilis,** 129

** 0.5 mm. long; basal joint of fifth foot long. . . . . **brevipes,** 130

b. Inner ramus of the first foot three-jointed.

* Inner ramus of the second foot two jointed.

† Antennæ thick. . . . . **crassus,** 130
†† Antennæ slender. . . **trispinosus,**‡ 130; and **northumbricus,** 130
** Inner ramus of the second foot three-jointed.
† Stylets rather long. . . . . **minutus,** 131
†† Stylets short, oval. . . . . **illinoisensis,** 131
II. Inner ramus of the fourth foot three-jointed.
a. Male antenna normal. . . . . **hibernicus,** 133
b. Male antenna reduced, hooked at the end. . . . . **palustris,** 133

[Not noted in the key are: **tenuicaudis,** 129; **northumbricus** var. **americanus,** 130; **borcherdingii,** 134; **minnesotensis,** 134.]

Canthocamptus elegantulus, *C. marcoticus* and *C. horridus* are uncertain, probably referred to the wrong genus. *C. stromii* Baird (= *Dactylopus stromii*), *C. rostratus* Claus (= *Stenhelia ima*). *C. virescens*, *C. linearis*, and *C. roseus* of Dana, are marine *Harpacticidæ* of uncertain affinities. *C. minutus* of Claus is not sufficiently described, but appears to be the earlier condition of *C. minutus* Mueller (*C. staphylnalis* Jurine).

* **Canthocamptus gracilis** Sars.

Is elongated linear, with the abdominal segment smooth. Caudal stylets long and slender; external caudal seta about one-fourth the inner. All the feet with two-jointed inner rami; outer branch of fourth foot longer than the others, inflexed; basal process of fifth foot slightly expanded. Length 1.0 mm.

(* **Canthocamptus tenuicaudis** Herrick.)

PLATE XXIX, FIGS. 15 and 16.

At Decatur, Ala., was found a species of *Canthocamptus* which is different from any American species, and seems in many points nearest the above, but, unfortunately, only a hasty sketch could be made at the time, and the notes are insufficient to define it. The form is not remarkably slender; the first and second abdominal segments are very large. The caudal stylets are slender and elongated, the inner seta being very long and curved, while the outer is quite short. The anal plate is covered with hairs only. The antennæ are normal, of moderate length, and the fifth foot has but a narrow process at the base.

If this form be worthy a distinctive name, it may be called *Canthocamptus tenuicaudis*.

‡ Distinguished from the following by the presence of only three spines on the process of the basal joint of the fifth foot.

Canthocamptus brevipes Sars.

This small form is almost certainly the young stage of some other species; yet I transcribe the description:

"Corporis forma et magnitudine C. pygmæo non dissimilis. Segmenta abdominalia vero postice magis attenuata seriebusque aculeorum destituta. Rami caudales elongati duplo longiores quam latiores, setis apicalibus brevisculis parumque divergentibus, exteriore dimidiam longitudinem interioris non attingente. Operculum anale absque dentibus. Antennæ 1-mi paris breves, articulis ultimis duobus in unum confluentibus articulum. Pedes natatorii brevissimi, ramo exteriore intus setis destituto, interiore biarticulato in pedibus 1-mi paris longitudinem exterioris æquante, in sequentibus multo breviore. Pedum 5-ti paris articulus basalis intus in processum foliiformem, sat magnum et angustatum, articulum ultimum elongato-ovatum aliquanto superantem, exit. Color albidus. Longit. parum supra $\frac{1}{2}$ mm."

Canthocamptus crassus Sars.

Robust; segments margined with pectinate bristles. Caudal stylets oval, contorted, constricted at the base. Antennæ thick, densely covered with long setæ. Fifth feet with long setæ; basal process rather small. All the feet excepting the first, with biarticulate inner rami. Length 0.75 mm.

Canthocamptus trispinosus Brady.

Plate L, Fig. 6.

This species with the last and next has all the feet save the first with biarticulate inner rami. Very near the next, from which it differs in the form of the fifth foot of the female, which has the basal process smaller, bearing only three spines, while the next has six, the second joint being longer and narrow. The male is unknown. Not yet identified in America.

Canthocamptus northumbricus Brady.

Plate XXIX, Figs. 20-22.

Body robust; antennæ long as first segment, nine-jointed; mandibular palp minute. In the male the inner branch of the third foot is three-jointed and dactylate, as in *C. minutus*.

* **Canthocamptus northumbricus** Brady. Var. **americanus** Herrick.

Plates XXIX, Figs. 6-14; XXXIII, Figs. 3-5.

One of our most common species is very near the English form; so near, in fact, that I dislike to remove it from it. A few points of divergence, however, may be mentioned.

The form and proportions are much like those of *C. minutus*. The head is large and ends in a prominent bent beak. The antennæ are

rather long and slender and have a well-marked flagellum. (Brady figures no flagellum.) The palp of the antennule is as in *C. minutus*. The mandibular palp is small. The first pair of feet normal, rather small; all the other swimming feet with two jointed inner rami, save in the case of the male third foot. The fifth feet are exactly as figured by Brady, save that there is a prominence or tooth of the basal segment near the point of attachment of the terminal joint which is quite long. The sensory area of the head is oval and pointed. The male antenna has a long flagellum, not, as figured by Brady, a very short one. The egg-sac is very large, oblong. The animal seems to fall short of the size of the English species, though measuring upwards of 0.65 mm. Our form is very well distinguished from any other species. It is found in Lake Minnetonka, Lake Calhoun, and elsewhere.

* **Canthocamptus minutus** Mueller.

PLATES XLVII, FIGS. 7-21; L, FIGS. 7, 8.

Monoculus staphylinus—Jurine.
Canthocamptus minutus—Lilljeborg, Baird, Sars, Uljanin, Brady, Herrick.
Canthocamptus staphylinus—Claus, Fric.
Canthocamptus minutus var. *occidentalis*—Herrick.

A well-known species which has been frequently described and seems quite circumpolar in its distribution.

First mentioned from America in a paper by the writer in 1878 A pretty full description will also be found in the author's *Types of Animal Life*. A very abundant species, frequent in muddy pools, but somewhat variable in abundance. It may frequently be found in great numbers in winter.

[The following description, compiled from *Types of Animal Life*, is inserted here for the convenience of those who are likely to use this report as a manual. H. F. N.]

Length about 1.0 mm. Antennæ a little longer than the first segment of the body; first three joints profusely covered with hairs; fourth joint more slender than the preceding and terminating in a process below, which bears, besides a long hair, a peculiar blunt bristle; fifth joint shorter than the rest; the remaining three joints are spined at definite points. The antennæ of the male are geniculate; the three basal joints are short while the three following joints are coalescent and are followed by a hinge joint of two elongated segments.

The antennules are two-jointed; the basal joint bears a two-jointed palp; the terminal joint is covered with spines; at the end there are three longer and curved spines, jointed in the middle, and the upper furnished with three small spines at the curve.

The mandible is a flattened toothed plate, bearing a two-jointed palp on one side and a blunt process on the other.

The first maxilliped is short and bears claws and spines. The second maxilliped is simple, three-jointed, and has a claw at the end.

The first pair of feet are biramose, each ramus being three-jointed; the outer ramus is shorter than the inner. The inner ramus of the fourth foot is two-jointed. In the male the inner ramus of the third foot is modified into a sort of grasping organ. The fifth feet are composed of two flat joints, larger in the female than in the male.

The first abdominal segment of the male carries a pair of three-spined processes. The last abdominal segment bears two stylets, each terminated by two long setæ, one being longer than the abdomen and longer in the male than in the female.

* **Canthocamptus illinoisensis** Forbes.

PLATE XXIX, FIGS. 1-5.

This robust and pretty species was first taken near Minneapolis by Mr. A. W. Jones, a student of the University, who found it in a peaty ditch. Forbes' description is appended.

"Length 1.0 mm. Head and first segment united; five abdominal segments in male, four in female. The suture between the first and second segments is not wholly obliterated above in the female.

"Last abdominal segment is deeply and acutely emarginate. Branches of furca as wide as long, inner bristle plumose, a little longer than abdomen; outer plumose only on outer side, about half the length of the inner. The second to fifth abdominal segments have each a row of spinules along ventral portion of posterior.

"Male with anterior antennæ composed of seven joints, the fourth joint very short. The front outer angle of the third is produced, the blunt process bearing three long bristles surrounding a slender olfactory club which is as long as the three following joints. The penultimate joint bears a strong spine or slender appressed process at the middle of its posterior margin. The five outer joints constitute the grasping organ. The posterior antennæ bear five long bristles at tip, three of which are made prehensile by the occurrence of from eight to twelve short articulations in the middle of the hair, allowing it to be bent forward. At the base of these articulations on the outer bristle are two short spinules. Two nearly longitudinal rows of five or six strong, short spines each appear on the under surface of the outer joint of the antennule. The secondary flagellum, borne as usual on the middle of the basal joint, is not articulated, and bears four long bristles, two terminal and two on distal half of inner side. The outline of the mandible is exactly like that figured by Claus, but it bears

about ten teeth, the upper thick and blunt, the inner sharp, slender and longer. Several are notched at tip. The lower angle bears a long simple bristle. Mandibular palpus two-jointed, second joint with three long terminal hairs and a shorter spine attached at basal third of anterior margin, jointed at base and directed towards tip, like a dactyl. The maxilla and maxillary palpus are scarcely to be distinguished from those of *C. staphylinus*.

"The first maxillipeds are three-lobed, the outer lobe constituting a long, strong claw. The second and third are about one-third as long as the first, and bear each one strong simple spine and one weak branched hair. The inner lobe is widest, about two-thirds as wide as long. The dactyl of the posterior maxilliped is spinous on its inner edge, and the same edge of the hand is ciliate and bears a short, stout, sparingly plumose bristle at its base, just beyond the tip of the closed dactyl. The width of this joint (the second) is nearly half its length.

"Basal joint of inner ramus of first pair of legs nearly or quite as long as outer ramus, the second wider but only half as long as the third, and obliquely truncate. Inner ramus of third pair of legs in male is three jointed [the outer two-jointed]*, chelate. The finger is ovate, truncate, terminating in two long plumose hairs. The dactyl is linear, curved at base, and twice as long as finger. The inner ramus of the fourth pair of legs is about half as long as outer, two-jointed, basal joint short, terminal joint about as long as middle joint of outer ramus. The fifth pair of legs is best developed in the female. In the male the length is not over one-third the width. The basal portion bears three plumose hairs on its very broadly rounded anterior margin, of which the innermost is longest. The outer plate is nearly orbicular and bears five spines on its terminal margin, of which the second from the internal angle is the longest. Genital plates, found in male at posterior border of first abdominal segment, beneath, are short, slightly expanded internally, with internal angles rounded, and externally bear three subequal bristles, jointed at base, the inner largest and strongest and semi plumose. The antennæ of the female are eight jointed, extending backward to the first free segment. The basal joint of the fifth pair of legs is subelliptical in outline, with the basal half produced externally into a broad, triangular process which bears the second joint on its posterior margin. The free end of the basal joint bears six large plumose bristles, of which the inner is longest. The greatest width of the joint is nearly equal to its greatest length. The second or outer joint is ovate, subtruncate, spined on each margin, and bears four plumose bristles at tip and one at the middle of its outer margin. Its length is about twice its breadth."

* Evidently a misprint, for it is the inner ramus which is chelate.

Canthocamptus hibernicus Brady.

PLATE L, FIGS. 3, 4.

A small species differing from all others save the next in having a three-jointed inner ramus of the fourth foot.

"Anterior antennæ of the female slender, eight-jointed, about as long as the first body segment, and much like that of *C. minutus*. Inner branch of the second antenna very small, one-jointed. Posterior foot jaw having a broad hand armed with a long apical claw. Inner branch of the first pair of feet scarcely twice as long as the outer; first joint longer than the entire outer branch, and nearly twice as long as the united second and third joints, both of which are extremely small. Inner branches of the second, third and fourth pairs shorter than the outer, and three-jointed, the first joint being very small. Inner segment of the basal joint of the fifth pair of feet in the female elongated, fringed, bearing two long and three short apical setæ; second or outer joint sub-ovate, finely fringed internally; externally bearing six long marginal setæ. In the male the limb is smaller, the basal joint short, broad and having six short setæ of equal length; second joint nearly like that of the female. Caudal segments somewhat longer than broad; inner seta about twice as long as the outer; anal operculum denticulate. Length 0.65 mm." Not found in America.

Canthocamptus palustris Brady.

PLATE L, FIG. 5.

A brackish-water species about 0.9 mm. long, found in a number of places in the British Isles. The species presents several anomalies.

The antennæ of the female are eight-jointed; those of the male robust, the last joint forming a hook. The first four pairs of feet have both branches three-jointed; the fifth pair in the female are two-jointed, with a short and broad basal joint, the second joint being sub-ovate, bearing five long apical setæ; in the male the fifth pair is obsolete, being reduced to a minute setiferous lobe. Caudal segments short, bearing two principal setæ, the outer half as long as the inner.

Canthocamptus borcherdingii Poppe.

Poppe '89.

The female is 0.64 mm. long. Caudal margins of cephalothoracic segments unarmed, but in the middle of each segment a transverse line of spinules. Abdominal segments spined beneath. Anal operculum with eleven teeth. Stylets short with two short unpectinate setæ, the inner half as long as the body while the outer is one-fourth. Antennæ eight-jointed, shorter than the first segment. Mandiblar palp

short, one-jointed, armed with three short setæ. The branches of the first foot are equal, the outer three-, the inner two-jointed. The joints of the latter are equal and spined laterad. The first segment bears on the mesal aspect a short seta, the second a short seta, and at the end a long seta and stout spine. The apical segment of the outer ramus bears a spine and at the apex a spine twice as long as the lateral one, a curved seta and a straight seta. The inner rami of the second to fourth feet are two-jointed. The fifth feet are exactly like Brady's *Attheyella cryptorum*, which Poppe thinks may have arisen by degenerative modification of this species.

The fifth feet of the male are two-jointed; the inner portion of the first segment is less developed than in the female and bears two short pectinate bristles. The oval apical segment has six setæ. The two inner ones are short and pectinate, the next is long, the next is shorter and finally two simple setæ. The inner ramus of the third leg of the male is three-jointed and is longer than the second joint of the outer. The first joint is very short with a small seta internally, the second segment is twice as long with a stout, curved pectinate seta, the apical segment is unspined but bears a long pectinate seta. Length of male 0.544 mm. Occurring in various fresh-water lakes of northern Germany.

* **Canthocamptus minnesotensis** Herrick.

PLATE XXII, FIGS. 1-6.

Since the manuscript of this genus was finished, a small species has been found which seems undoubtedly distinct from any of the above. A single pair were taken in a gathering from Bassett's creek containing *C. minutus* in abundance. Unfortunately the characters of the swimming feet are not certainly known, but they were apparently all three jointed save the last. The antennæ are very short and thick, eight-jointed, with a long flagellum; the antennules are of the usual form, and the mouth parts rather large. The first pair of feet have the two rami of nearly equal length. The form is moderately elongate. The caudal stylets are very short, quadrate in outline and well armed with spines. The fifth foot of the female has four long and two short spines on the inner lamina, and the terminal joint has five unequal spines. In the male the fifth foot has two spines on the lamina and six on the second joint, one being a small bristle. The male antenna is of peculiar form. The teeth of the anal plate are large and emarginate (see Fig. 4).

The swimming feet are all armed with very strong spines, aside from the usual quota of spines at the end of each joint. Length 0.65 mm.

GENUS ATTHEYELLA Brady.

This genus, the diagnostic characters of which have been above indicated, contains three nominal species. It is quite difficult to say what differences exist between Sars' *Canthocamptus pygmæus* and *Attheyella spinosa*. Brady did not seem to recognize the fact that his diagnosis included that species. The third species is the blind *A. cryptorum* of Brady, which it is interesting to compare with the blind *Bradya limicola* of the coast of the Gulf of Mexico.

GENUS MARSHIA Gen. nov.

Allied with *Attheyella*. Inner branch of first foot three-jointed, scarcely elongated, barely subprehensile. Second and third feet with outer ramus two-jointed, short. Fourth foot with minute one-jointed outer ramus and three-jointed inner ramus. Fifth feet one-jointed. Antennæ six-jointed, the fourth joint with a slender hyaline process longer than the end of the antenna. Second antennæ without obvious palpus, prehensile. Mandiblar palp simple? First foot-jaw with an uniciliate papillose palpus. Second foot-jaw with a long uncinate special joint. Antennæ of the male strongly modified. Habit, fresh or brackish waters.

*Marshia albuquerquensis sp. n.

PLATES XXXI; XXXII, FIGS. 1-5.

Body with ten obvious segments, with the aspect of *Canthocamptus*. Antennæ short, six-jointed. The proximal joints enlarged and spinous; second also tumid, with three or more cilia; third joint longer; fourth with a long seta and still longer flagellum; fifth joint very short; apical joint elongate bearing about ten setæ. Antennules short, prehensile, with four geniculate setæ apically and several short spines, especially a transverse series of sharp teeth on the dorsal aspect. Jaws with six sharp teeth. Anterior maxillipeds with a minute unisetose palp and three processes bearing curved spines. Posterior

NOTE.—*C. frontinalis* Rehberg. This author seems to have parted with his usual acumen in the remarks upon this species. After describing a *Canthocamptus* with the inner ramus of the first foot "reichlich doppelt so lang wie die beiden Grundglieder des Aussenasts," he draws a moral on the mutability of genera from the fact that Brady founded the genus *Attheyella* "auf grund der Eingliede des innenastes am fierten Fusspaare und einer derartigen Bildung des ersten Fusses, wie er bei *C. frontinalis* beschrieben ist." Brady says (*Brit. Copepoda*, p. 58): "Inner branch of first pair of feet scarcely at all elongated, and either two- or three-jointed," etc. The distinctive characters being the one- or two-jointed second and third feet and the one-jointed inner ramus of the fourth foot, it is doubtful if *C. rontinalis* is really new.

maxillipeds with a long claw longer than the preceding joint. First foot with the outer ramus nearly as long as the inner, two-jointed, bearing at the apex three pectinate setæ. The basal joint bears a pectinate seta externally and a spine internally. The inner aspects of all the joints of both rami are spinous, the outer setose. The outer ramus of the second foot is two-jointed and has one pectinate seta apically, one spine internally and one spine externally, while the corresponding segment of the third foot has two pectinate setæ apically and one internal seta and two external spines. The fourth foot has a minute one-jointed outer ramus bearing one long pectinate seta and a short external spine. The fifth foot seems to consist of one piece, armed as follows: Externally a conical projection near the base with a long simple seta, outer apical lobe (= the homologue of second joint) with five setæ, the second and fourth of which are longer and pectinate; the inner apical lobe bears six (or five) setæ, all but the innermost being pectinate. The two lobes are separated by a simple incision, and repeated examination showed no indication of any segmentation in either sex. The abdomen is very slender, and, like the thorax, its segments are all ornamented caudad with a series of spines or teeth. Stylet two and a half times as long as wide, with one or two small spines externally one third the length from the base and one longer spine near the middle of the inner margin, which is ciliate. The two median apical setæ are fused at the base and the inner is three times as long as the outer, which is twice as long as the stylet. The inner apical seta is short, the outer obsolescent.

In the male the antenna is reduced to a thick tumid member with the third and fourth segments greatly enlarged. The apical segment is furnished with three hook-like claws. Flagellum slender, of uniform diameter. Fifth foot has on the outer apical lobe four setæ and a small spinule, and on the inner three non-pectinate setæ. Caudal stylet greatly elongate, over four times as long as wide and nearly twice as long as the preceding segment.

Marshia brevicaudata sp. n.

PLATE XXXII, FIGS. 6-13.

The second species of this genus at present known may be described comparatively. Similar to *M. albuquerquensis* in most respects, but differing in a few points so far as known. The caudal stylets are short, about twice as long as broad, the longest seta being seven times the length of the stylet, while the outer median seta is twice and a half as long as the stylet. These setæ are not fused at the base. In the male the difference between the species is greater. The proportions of the stylet being the same as in the female, but the longest seta is

nine times as long as the stylet. The fifth foot of the female nearly as in the previous species, but the proportions of the setæ differ. The fifth feet of the male are like those of *M. albuquerquensis*. The antennæ of the male seem to be different. In *M. albuquerquensis* the apical segment is larger and the flagellum is long and of uniform width, while in the present species the flagellum is short and clavate. The swimming feet seem similar. Length of male 0.56 mm., length of first segment 0.15 mm., length of stylet 0.04 mm., length of longest seta 0.28 mm. to 0.34 mm.

The stylets in the female of *M. albuquerquensis* measure 0.072 mm. in the female and over 0.08 in the male, the longest seta being 0.37 and 0.42 respectively.

It must remain for larger experience to determine the value of these distinctions, which rest on comparatively few individuals in the case of *M. brevicaudata*.

PART II

CLADOCERA OF MINNESOTA

BY C. L. HERRICK

ORDER CLADOCERA.

This very extensive group contains a variety of types, but there are sufficiently evident connecting links uniting the extremes of structure. The *Gymnomera* which, following the usual custom, we include here, stand distinct from the other groups, yet have sufficiently evident cladoceran affinities. It is very unfortunate for ætiological speculation that this the only truly marine group should stand thus isolated from its fellows. According to the notions at present prevailing, the *Phyllopods* stand nearest the primitive type of crustacea. There are unmistakable hints at an early origin for that group, and not less evident are certain analogies with both *Cladocera* and *Copepoda*.

There has, however, recently been made an attempt to derive the *Phyllopods* from an original cladoceran stem with, as we think, somewhat unsatisfactory results. Do we not rather see in both groups two like phases which may be looked upon as incidental and comparatively trivial? The shelled and the shell-less phases appear in both. The most closely shelled *Phyllopod* is unmistakably nearer *Branchipus* even than any of the *Cladocera*. It would seem that the brief and imperfect embryonic nauplius condition of the latter sufficiently indicated their later origin. Again, no fanciful analogy can unite the *Ostracoda* with the *Lynceidæ*. We know of no recent discoveries casting discredit on the remark of Balfour: "The independent origin of the *Ostracoda* from the main crustacean stem seems probable."

Professor Packard says:*

"We imagine that when a permanent body of fresh water became established, as, for example, in perhaps early Silurian times, the marine forms carried into it in the egg-condition, possibly by birds [sic?] or by high winds, hatched young, which, under favorable conditions, changed into *Sida*, *Moina* and *Daphnia*-like forms. The *Cladocera* are, then, probably the more generalized forms, from which the *Phyllopods*, at this time, and probably ever since Devonian times, *par excellence* a fresh-water assemblage of forms, took their origin. Whatever affinity there may be between the shelled *Phyllopods* and the

*"A Monograph of the Phyllopod Crustacea," etc., *XIIth Annual Rep. U. S. Geol. and Geog. Surv. Terr.*

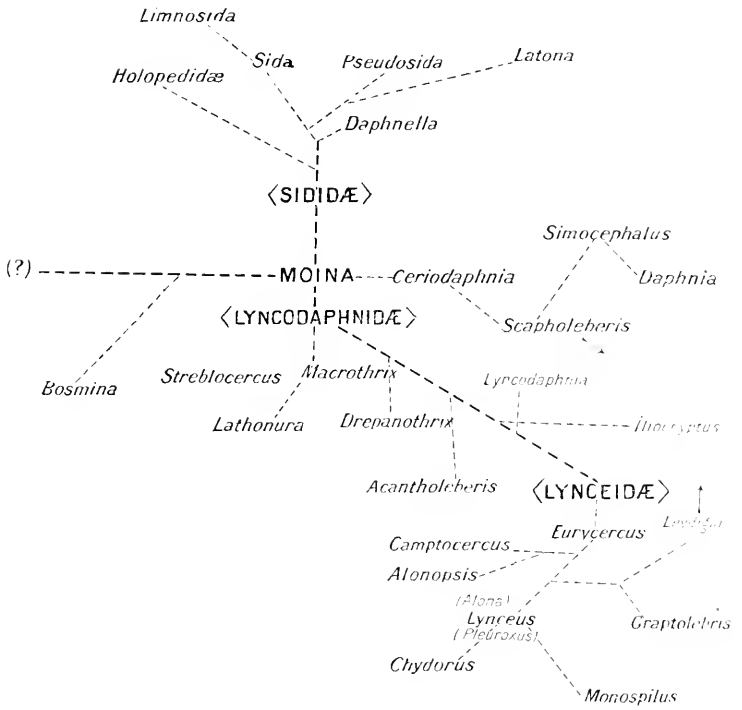
Cladocera, it would seem that the evidence is conclusive that the latter group is not the direct continuation of the line of development inaugurated by an ostracode ancestor. As shown beyond, the present centre of the group seems near *Moina*, with indications of a divergence from this rather generalized type, especially of degradation and heteronomy on the side of the *Lynceids*.

It seems at the present time that more might be accomplished for ætiology by a careful study of such groups as the present, in which are a variety of closely allied forms, than by the attempt to join widely separated groups. When we shall have seized upon the latest eddies and mapped their direction, it may become possible to combine the indications in such a way that lines of divergence thus traced accurately through some small part of their course may be produced backward to their intersection. This, then, is our present duty—the accurate mapping of minute districts and the careful noting of any moving straws competent to indicate movements in the vast complex of vitalized nature. We conceive the *Cladocera* to have had a comparatively recent origin, and to express the culmination and retrogade development of a plan of structure first differentiated after the appearance of clear bodies of fresh water. All the species save a very few are confined to inland waters. Accepting the above mentioned theory, the *Sididæ* will occupy the first place as departing least from the type from which the whole group sprang, while it is connected by the genus *Daphnella* with the *Daphnidæ*. The *Daphnidæ*, beginning with *Moina*, find their ultimate development in some monstrous forms of the genus *Daphnia*, but pass into the *Lyncodaphnidæ* by way of *Macrothrix*. The links uniting all these minor groups are very obvious.

Our own ideas of the relationships among the *Calyptomerous Cladocera* are expressed in the accompanying table. This table is to be considered a projection of a portion of a genealogical tree, seen from below, in which the genus *Moina* forms the arbitrarily chosen fixed point. The heavy dotted line is imagined as directed downward vertically. That branch rising toward the top of the page is growing obliquely upward. The *Daphnidæ* are represented as expanding upon the same plane as *Moina*, and the *Lyncodaphnidæ* extend diagonally downward, producing the *Lynceid* branch. The *Bosminidæ* spring from the stem at a lower point.*

The *Cladocera* or *Daphnoidea* are characterized by the more or less leaf-like feet and the lamina of thin chitine which incloses the greater

* NOTE.—To adapt the diagram to the theory that the *Lynceidæ* are the progenitors of *Cladocera*, it is only necessary to revolve the imaginary line to the right, till it coincides with the axis of that family. The question mark may be understood to indicate that the source of the pivotal group, *Moina*, is uncertain. The author must confess that his inclination is toward a belief that the line culminating in the *Daphnidæ* diverged from a group of organisms resembling *Phyllopoda*, more definitely, resembling *Limnetes*. There is a very remarkable resemblance between the larva of *Limnetes* and *Bosmina*. The lateral spines of the former are, as will be shown, true homologues of the antennules of *Bosmina*. The later origin of the *Phyllopoda* in their present form may be well admitted.



part of the body, or at least forms a sac for the protection of the eggs. This so called shell springs as a fold from the maxillary segment, and is the most conspicuous and variously formed, while really least important, of the structural peculiarities.

All *Cladocera* begin life with a single median eye, but some lose it during later life. In one case it remains the only visual organ.

The outer covering is in most cases changed by frequent moults. The period of the moult is one of the most precarious in the life history of the animal.

Although figures and brief descriptions of animals belonging to this group are to be found in the works of Swammerdam, Leuwenhoek, Trembley and others of the older authors, Mueller* was the first to produce a systematic work upon these in common with other minute fresh-water crustacea. He may be called the father of the study of micro-crustacea. Jurine,† an eminent Swiss naturalist, was the next to contribute important discoveries relating to these interesting animals, though Ramdohr had given anatomical details of sev-

* Entomostraca, seu Insecta testacea, quæ in aquis Daniæ et Norvegiæ reperit descripsit, etc. *Otto Friedrich Müller*, 1785.

† Monoc. qui se trouvent aux Envir. de Geneve.

eral species. Gruithuisen, a little later, gives further details of *Daphnia sima* (*Simocephalus*). The work of Milne Edwards gives a resume of what was known regarding these animals in that period. Soon afterwards the work of Baird became the beginning of a new era, and the study of the minute crustacea sprang into importance at once. The Scandivanian peninsula being the birthplace of the science, it is proper that the most exhaustive work on the group should be performed there.

The most important of the later writers are Leydig, Schoedler, Fischer, Lilljeborg, P. E. Mueller, Sars, Weismann, Claus and Kurz.

The complete bibliography of the subject up to Mueller's time is found in Baird's *British Entomostraca;* the greater part of the later bibliography is to be found in P. E. Mueller's *Danmark's Cladocera.* A few only of the more important works are here mentioned, the complete list elsewhere given making repetition unnecessary.

Lilljeborg, W., De Crustaceis ex ordinibus tribus, (or) Om de inom Skane forekommande Crustaceer af ordningarna Cladocere, Ostracoda och Copepoda.

This valuable work is particularly good on the *Cladocera*, but is unfortunately without Latin descriptions; so that the Swedish text is a hindrance to its usefulness. It is chiefly of historic value now. Large 8vo. Lund, 1855.

Leydig, Fr., Naturgeschichte der Daphniden.

The most magnificent work published on this group.

Sars, G. O., Om Crustacea Cladocera, iagttagne i Omegnen af Christiania, 1862.

This valuable work is difficult of access, printed on thin paper and without illustrations. A second paper by the same author in 1863 is mentioned, but I have never seen it.

Schoedler, J. E., Neue Beiträge zur Naturgeschicte der Cladoceren, 1863.

One of the most important works on the *Lynceidæ.*

Sars, G. O., Norges Ferskvands'krebsdyr Cladocera ctenopoda, 1865.

The best work on the *Sididæ*, etc.

Mueller, P. E., Danmark's Cladocera.

One of the most useful books on the subject. Especially good on *Lynceidæ* and *Bosminidæ.*

Grobben, C., Zur Entwicklungsgeschichte d. Moina rectirostris, 1789.

Weismann, Beiträge zur Naturgsch. der Daphnoiden, Leipzig, 1876-79. (Valuable on the physiology.)

The American literature may be catalogued in a few lines. The first descriptions and figures with which I am familiar are those in the *Report of the United States Fish Commision, 1874*, where S. I. Smith

notes *Daphnia galeata, D. pellucida* and *D. pulex;* also a species of *Bosmina, Eurycercus lamellatus* and *Leptodora hyalina.*

A. E. Birge was the first to systematically study *Cladocera* in America, and his *Notes on Cladocera* furnished a basis upon which to build. A few notes were published by the writer a little later.

A few additional notes and descriptions of new species were published in the *Eleventh Annual Report of the Minnesota Geological and Natural History Survey.*

Professor Birge published other notes in the *Medical Journal and Examiner* of Chicago, which I have not seen.

Professor Forbes of Normal, Ill., in an article in the *American Naturalist*, July, 1882, adds a number of facts and one new species.

In addition to the above, a figure of *Sida* was printed in one of *Hayden's Survey Reports*, and some account of the *Cladocera* of Lake Michigan was given by B. W. Thomas, I believe, in one of the official reports of the Chicago Water Commission.

Since the publication of the first edition several papers by Professor Birge, Professor Turner and the writer seem to be the only ones requiring notice.

KEY TO THE ORDER CLADOCERA.

I. Body enclosed in a bivalve shell. Mandibles truncate below. Maxillæ distinct, spiny. Thoracic ganglia discrete. (Sub-order **Calyptomera.**)

a. Six pairs of feet, similar, foliaceous, all distinctly branchiate. (Tribe **Ctenopoda.**)

* Swimming antennæ with two unequal rami, intestine simple. Family **Sididæ,** 146

** Swimming antennæ simple, elongate cylindrical (in the male prehensile); intestine with two lateral dilations. Family **Holopedidæ,** 151

b. Five (or six) pairs of feet, the anterior pair more or less prehensile and destitute of branchiæ. (Tribe **Anomopoda.**)

* Rami of antennæ three- and four-jointed; five pairs of feet, the last with a curved appendage guarding the branchial sac; antennules of the female short, one-jointed. Family **Daphnidæ,** 152

** Six pairs of feet; antennules elongated, many jointed. Family **Bosminidæ,** 206

*** Antennules of female elongated, but one-jointed; intestine simple or convolute. . . . Family **Lyncodaphnidæ,** 209

**** Antennæ with both rami three-jointed; intestine convolute, with abdominal but no anterior coeca. Family **Lyncidæ,** 224

II. Body without or nearly destitute of a bivalve shell; feet not branchiate, spiny; anterior thoracic ganglia in one mass. (Sub-order **Gymnomera.**)

a. Abdomen curved, terminating in two long stylets. Family **Polyphemidæ,** 266

b. Abdomen straight, ending in short claws. Family **Leptodoridæ,** 268

CLASSIFICATION OF THE CLADOCERA.

SUB-ORDER I.—CALYPTOMERA (membrane-clothed).

TRIBE I.—CTENOPODA. Families: *Sidide, Holopedidæ.*

TRIBE II.—ANOMOPODA. Families: *Daphnidæ, Bosminidæ, Lyncodaphnidæ, Lynceidæ.*

SUB-ORDER II.—GYMNOMERA (destitute of covering).

Families: *Polyphemidæ, Leptodoridæ.*

FAMILY SIDIDÆ.

Head separated from the body by a depression, without prominent fornices (or spreading shields) over the base of the antennæ. First pair of antennæ, or antennules, as we shall uniformly call them, one-jointed, usually rather small in the female, but extending into a very strong flagellum in the male. Antennæ long, biramose, with unequal branches. Mandibles truncate at the end. Maxillæ armed with large spines. The form is usually elongate, and the abdomen often extends beyond the edge of the shell behind. The male openings are usually in the end of long appendages which depend from the base of the post-abdomen. This interesting family is represented in America so far by four species, one of which constitutes a new genus. Others will undoubtedly be found upon a careful study of the fauna of the Great Lakes. Most of the species prefer the clearer and colder water of large lakes. The processes of development, as traced by the writer, vary very little from the method exhibited by *Moina*. The ephippial condition, however, is not found in these animals which are less subject to destructive influences of the climate. They do, however, produce so called winter eggs, which are laid in October and are distinguished from the summer eggs, which hatch in the brood cavity, by a brown color and the presence of fatty spheres. These eggs are produced in large numbers in distinction from most other *Cladocera*, in which the winter eggs are very few. These eggs are permitted to settle to the bottom and there develop at the proper time. *Sida crystallina* is often found in immense numbers in large lakes which contain abundant plant growth. The size, and especially the reproduction activity, is very dependent on the environment, and hence little success is obtained in preservation in aquaria. Some of the genera are nocturnal and should be sought at the surface on quiet evenings.

GENUS SIDA Straus.

Body elongate, hyaline. Head small, quadrate. Fornices absent. Antennules of female small, truncate; of male, with a long flagellum. Second antennæ with the rami two- and three-jointed. Male with the

sexual openings just behind the last pair of feet. It is the upper or longer branch of the antennæ which in *Sida* is three-jointed, while the reverse is the case in the next genus. The only species, according to P. E. Mueller, is the ubiquitous

* Sida crystallina.

PLATES XXXV, FIGS. 13-15; XXXVII, FIGS. 1, 2.

P. E. Mueller (Daphne crystallina); Latreille (Daphnia crystallina); Straus; Milne-Edwards '34-40; Gmelin, Manuel, Fabricius (Monoculus crystallinus); De Geer 1778 (Monoculus elongatus); Lievin '48; Baird '50; Lilljeborg '53; Fischer; Schoedler '58 and '63; Leydig '60; Sars '65 (elongata, and crystallina; P. E. Mueller '68; Kurz '74; Birge '78; Herrick '79, '82 and '84; Lutz '79; Weismann; Grobben '79.

The *S. elongata* of Sars is distinguished by the smaller head and its concave lower margin and more elongate shell. The terminal joint of the longer ramus has one less seta than *S. crystallina*, while the post-abdomen has more numerous spines. We incline to believe it a valid variety at least.

GENUS PSEUDO-SIDA Herrick.

Similar to *Sida*. Antennules of the female with a long flagellum, like that of the male of *Sida*, sensory setæ lateral. Body elongate, head short, extending into a sharp beak. The post-abdomen is armed with groups of sharp spines or bristles. Most characteristic, however, is the fact that the antennary joint, which in *Sida* is two jointed, in this species is tri-articulate, and the two-jointed ramus has a great number of setæ (16 to 17).

*Pseudo-sida tridenta Herrick.

PLATES XXXVI, FIGS. 2-6; L, FIG. 9.

Herrick '84 (bidentata. By oversight the number of caudal teeth was misstated and the name made to correspond.) and '87.

Head very short, acute below, the beak bearing in the female a pair of rather large antennules which are armed with a pectinate process three times the length of the antennule, and a cluster of about five sensory setæ. The antennæ are as long as in *Sida* and well armed. The basal joint of the two-jointed branch bears seven setæ, the second ten setæ of which two are apical; three-jointed ramus with very short basal segment, second four times as long as wide and armed at the end with two setæ and a spine; third segment very small, with three setæ and a minute spine. The maxilla is two-jointed, the terminal joint bearing nine jointed spines or short setæ. The first foot of the adult

female is biramose, the outer ramus being large, its terminal joint bearing seven pectinate processes; the preceding segment has two processes on the outside, while the short basal joint has a very large process, the outside of the base of the limb, with three similar processes, inner ramus with five setæ on the third and four each upon the second third, inner margin of base of limb produced to form a multisetose branchial fin. Post-abdomen rather small, its terminal claws short and armed with three basal spines and a series of spinules along the inside, post-abdomen also ornamented with about twelve clusters of teeth along the posterior margin and about the base of the claws. The eggstalk is long and about three out of every four eggs produced parthenogenetically serves as nourishment for the fourth, the ephippial females (i. e., the late females which produce eggs coated to resist cold or drouth) are smaller than the ordinary examples and produce two very large ova.

The shell is ornamented along the ventral margins with short spines and along the free caudal margin with minute hairs. In most respects this species is like *Sida*, which it resembles in size. In the form of the female antennæ it is like *Latona*, which it also somewhat resembles in the number of joints of the antennæ and the numerous setæ they bear. It is certainly an interesting transition form. Found only in swamps bordering Mobile Bay, Ala., but whether in brackish or fresh water my notes do not inform me. *Sida crystallina* lives far out in the bay, and *Daphnella* is found in pools along shore.

GENUS LIMNOSIDA Sars.

PLATE XXXV, FIGS. 9, 10.

Head crested: eye in a conical prominence. Shell elongated, produced above in an acute angle. Antennules small, truncate in the female; in the male of enormous size; antennæ very long. Post abdomen smooth; terminal claw spiny.

The one species, *L. frontosa* Sars, is not yet known in America.

GENUS DAPHNELLA Baird.

Neither beak nor fornices present. Antennules of female small, truncate; those of male long, flagellate. Antennæ with two and three-jointed rami. Male with a hook on the first foot, and large copulatory organs attached to the base of the post-abdomen.

*Daphnella brachyura Lievin.

PLATE XXVI. Figs. 11-16.

Lievin '48; Baird '50 (wingii); Lilljeborg '53 (Sida branchyura); Fischer '54 (Diaphanosoma brandtianum); Sars '65 (Daphnella brandtiana); P. E. Mueller '68 Daphnella brachyura); Pavesi '79 (Sida brachyura); Herrick '82; Birge '78.

The species of *Daphnella* found about Minneapolis, occasionally abundant, seems not to differ in any important character from European types of *D. brachyura*, although I formerly regarded it as distinct (*D. winchelli*, Microscopic Entom., Addenda).

Head less than one-half the body (about 0.27 mm., while the body is 0.6 mm. long); eye about one-fourth head; antennæ when reflexed extend a little beyond two thirds the length of the body. Male, 0.7 mm. long; antennæ reflexed, reaching base of shell; anterior antennæ extremely long; copulating organs reaching nearly to end of claws. Having carefully compared our specimens with the descriptions and figures given by Birge for his *D. cspinosa*, the evidence seems to indicate not only that they are identical, but both are really *D. brachyura*. The distinctive characters of *D. cspinosa* are a greater indentation between head and body, absence of caudal teeth, greater length of male appendages, and the opening of the vasa deferentia below the "instep" of these appendages.

The absence of teeth upon the post-abdomen is of even generic importance according to Sars, who gives it in his synopsis of genera as typical for *Daphnella*. In our specimens the claws are at least pectinate if not serrate, while the appendages of the male reach generally nearly to the middle of the claws. The relative length of these appendages and the antennæ of the male is variable.

Daphnella brandtiana Fischer.

PLATE XXXVII, FIGS. 3-6.

Head as long as half the body, antennæ when reflexed reaching beyond the posterior margin of the valves. Length 0.8 mm. Of the validity of this species we can form no conclusion. It is usually considered a variety or phase of the above.

Daphnella excisa Sars.

Sars '85 (Diaphanosoma excisum).

Similar to *D. brachyura*. Head obtusely truncate cephalad, without distinct sinus beneath the eye, dorsal margin slightly arched. Carapace oblong, truncate posteriorly with the dorsal angle nearly a right angle, valves inflected in the middle and wide open posteriorly, having a well marked angular emargination at the junction of the ventral and caudal margins. Eye large. Antennæ, when reflexed, not reaching the caudal margin of shell. Length 1.30 mm. The head occupies about one-third the entire length. The apical claws are armed with three teeth.

GENUS LATONA Straus.

PLATE XXXV, FIG. 8.

Body elongate, broad; head large and square, appendaged below with triangular laminæ; fornices present. Antennules rather large. The larger ramus of the antennæ is two-jointed and has an expanded process at the base. The lower posterior angle of the shell has a peculiar diverging set of setæ. The shell is often ornamented with numerous flecks of bright color. There is a copulatory apparatus in the male.

* **Latona setifera** Mueller,

Is the only species, and is not yet recognized in Minnesota, but was found by Professor Birge in Lake Michigan.

Professor Birge mentions "one peculiarity not mentioned by any European writer. There is a thick coat of short hairs on the head, body and antennæ. These hairs are 0.02 mm. or less in length, are close set and give the outline a velvety appearance when seen by transmitted light. It lives in clear water among weeds."

GENUS LATONOPSIS Sars. 1888.

Allied to *Latona*. Impression between head and thorax slight or absent. Labrum devoid of plate like expansion. Antennule with a long, plumose, straight or curved flagellum, articulated to the basal part. Antenna with simple rami, the superior ramus bi-articulate, the inferior tri-articulate, as in *Daphnella*. Heart concave dorsally, truncate anteriorly, the aorta arising on the ventral side. Shell gland with three long branches. Male with simple copulatory organ, and hook on first leg. Antennule long, slightly curved, armed with fine teeth, resembling in general the antennule of *Sida* but having a median projection near the base.

* **Latonopsis occidentalis** Birge.

PLATE XXXVIII.

Birge '91.

Anterior outline of head forming a nearly straight line from the antennules to the eye, where it passes by an abrupt curve into the nearly straight continuous margin of the shell, which, however, becomes convex in old females. The ventral margin is continued into the labrum and lacks the leaf-like appendages of *Latona*. Small bilobed fornices are present. The ventral margin of the shell is evenly rounded, passing without marked projection into the straight caudal margin. The edge of the shell is fringed with long plumose

setæ, of which three at the lower caudal angle are enlarged and divergent. Surface of shell smooth. Antennules composed of a nearly cylindrical basal part and a much longer, curved, tapering, hairy flagellum. Sensory setæ about eight at the posterior side of the distal end of the base. Antennæ with massive basal portion bearing a dorsal bi-articulate and a ventral tri-articulate ramus. The basal joint of the former has four to five setæ and a spine, and the apical joint seven setæ and a spine, while the second joint of the latter has one seta and a spine, the apical four setæ. The post-abdomen is short, fleshy, obtusely conical, and armed with nine supra-anal denticles. The terminal claws are strongly curved and have two secondary teeth. The antennules of the male resemble those of *Daphnella*, and form near their bases is a ciliated appendage. The copulatory organs resemble those of *Latona*, and the first leg has a strong hook. This species was found by Birge in a small lake in Wisconsin.

The remaining species of the genus *L. australis* Sars is exceedingly close, but the fornices are said to be absent and the antennules are shorter than the anterior margin of the head. We have encountered this interesting species at Albuquerque, New Mexico, and are inclined to believe it southern in range, only sporadic in the north.

FAMILY HOLOPEDIDÆ.

Body inclosed in a hyaline, gelatinous envelope. Head small, depressed. Antennules short, immovable, alike in both sexes. Antennæ uni-ramose in the female, in the male a small rudiment of a second ramus present. Mouth parts not covered by the shell. There are six pairs of lammellate swimming feet. No external copulatory organ.

GENUS HOLOPEDIUM Zaddach.

The characters are those of the family.

* Holopedium gibberum Zaddach.

PLATE XXXV, FIG. 11.

Zaddach '56; Sars '62 and '65; Mueller '68; Fric '72; Hellich '77; Forbes '82; Herrick '84; Birge '92.

The small head is depressed and conical, beakless. Eye small, with few lenses. Pigment fleck large, at the base of the antennules, which are short, cylindrical, slightly expanded in the middle. There are three apical setæ at the end of the second joint of the one-branched female antennæ. Shell sculptureless, its lower free margin is toothed caudad. Post-abdomen short, conical, straight, armed on either side

with about ten teeth. The claws are short and curved and have one basal spine and fine teeth. The palp of the male antenna has two setæ.

This species has been found near Madison by Birge and by Forbes in Lake Michigan.

FAMILY DAPHNIDÆ.

The family *Daphnidæ* contains the genera *Moinadaphnia*, *Moina*, *Ceriodaphnia*, *Scapholeberis*, *Simocephalus* and *Daphnia*, which include the commonest, as well as some of the largest, *Cladocera*. The genera may be distinguished by the following table:

I. Head rounded, not beaked; antennules long in both sexes, shell not covering the end of the abdomen.
   a. Abdomen with process of abdomen to retain ova, . **Moinadaphnia,** 166
   b. Abdomen without the process in ordinary females, . . . **Moina,** 160
II. Head rounded; antennules rather short; shell inclosing whole body, ... **Ceriodaphnia,** 167
III. Head somewhat beaked below; shell angled below or extending in long spines from lower angle, pigment fleck roundish, **Scapholeberis,** 174
IV. Head beaked below; shell rounded below, with a blunt spine above; pigment fleck elongate, ... **Simocephalus,** 177
V. Head beaked below; shell extending in a sharp spine at the upper posterior angle; pigment fleck small, ... **Daphnia,** 181

The Circulatory System of the Daphnidæ.

PLATE LI.

In the *Daphnidæ*, and, indeed, the *Cladocera* in general, we meet an instance of great development of surfaces at the expense of solidity of form and compactness of organs. The whole body is composed of an aggregate of laminæ, and the appendages all approximate more or less toward this fundamental modification. Thus, for example, the head is a leaf-like body with a laminate shield above and a pair of flat organs beneath. The abdomen terminates in a knife-like post-abdomen, while the thorax, with its narrow form, foliaceous feet and, far more, the enormous development of the outer wall to inclose, more or less fully, the entire body, is the typical illustration of this fact. Necessarily this structural modification exerts a formative influence on the internal organs which are all more or less influenced by it; and this is peculiarly the case with the more external and, in general, the paired organs. Thus the "shell glands," so called, which in *Copepoda* are generally coiled tubes, become here greatly flattened organs closely united with the shell. The physiological result of this modification is the sensitiveness to changes in the environment, which is universal

among the *Daphnidæ*. The compact *Copepoda* survive the vicissitudes of confinement with comparative immunity, but the first taint in the water destroys the delicate organism of *Daphnia*. The cause for this may be found in the exposure of the most vital and delicate parts of the organism to the influences of the surrounding aqueous medium. In particular the circulatory and respiratory systems, which here are not easily to be distinguished one from the other, constitute a relatively very large area of close contact with the water. It thus happens that the central organs are influenced in a very short time by whatever deleterious substances may be disseminated in the water.

Notwithstanding this lack of centralization, the structure of these animals is of a very considerable degree of complexity and, presenting so many instructive modifications under circumstances so favorable for study, has been very thoroughly investigated. The very transparency which has made it possible to clear up many questionable points in crustaceology from the lessons learned in *Daphnia* has rendered the investigation of certain sets of organs extremely difficult, and among these may be mentioned the circulatory system. The circulation of the nutritive fluid and the general facts connected with the heart were indeed early understood; but there remain many a detail and some important relations which are as yet either imperfectly known or entirely misunderstood. The following notes are offered as a contribution to the, as yet incomplete, knowledge of the circulatory apparatus.

The observations were confined for the most part to *Daphnia schæfferi* and *Simocephalus vetulus*, with occasional comparisons with *Eurycercus*, *Pleuroxis*, *Pasithea* and others. It is greatly to be desired that the study might be carried to the *Sididæ*, in which the larger size and superior transparency would doubtless reward the search with several, as yet doubtful details. The circulation of the nutritive fluid in the *Daphnidæ*, then, is somewhat complicated, but may be divided into a superficial and a deep system. It must be remarked that this distinction is arbitrary and only used for its convenience. The one extends over the entire inner surface of the carapace, while the latter is in close relation with the vegetative organs, and extends into the branchial vessels of the feet. The nutritive fluid which is normally colorless and supplied with corpuscles of organized nutriment (it seems doubtful if they should be called blood corpuscles), is confined for the most, if not its entire, course within membranous walls of connective tissue which, however, instead of assuming a definite form as "blood vessels," for the most part conform to the contour furnished by the firmer organs.

This membrane, which is frequently folded upon itself and invests the body walls and the inner organs, is in some places free, and may be seen as a pulsating, swinging film, or, more frequently, it can only be detected as a swaying line (seen in optical sections), thus giving rise to the misapprehension that one is dealing with a thread, or as moving grains, in which case the film is itself invisible but its presence is indicated by the attached grains of protoplasm. About the heart the free swaying portions of this membranous layer are so numerous as to render it almost impossible to distinguish the essential from the accidental appearances.

This membrane must serve the most various purposes; aside from the mere retention and direction of the blood currents, it is often transformed into a branchial surface. At definite points it becomes the bearer of the cells which were above mentioned as grains of protoplasm. These are most numerous in young and well-fed animals, and in particular in gravid females, while, on the contrary, mature males and females after the escape of the young, are nearly devoid of such bodies. These are most numerous in the angles of the membrane, particularly about the heart, shell glands, ovaries, intestine and the branchial spaces in the feet.

These cells vary in size from that of the blood corpuscles to larger cells with nuclei of comparatively very large size. It would be too much to say that such cells are developing blood corpuscles; but that they are reservoirs of nutriment which serve to supply the increased demand upon the blood in exigencies of the existence of the animal, cannot be doubted. It is a well-known fact that the number of blood corpuscles, so called, likewise varies, and apparently under the same conditions. It seems altogether probable that the two facts may be considered as supplementary, i. e., that the same process of depauperating of the blood, which deprives it of its corpuscles in an earlier stage, lays waste those supplies laid up in the cells referred to (whether by their actual separation as blood corpuscles or simply dissolving of the contained material is of little importance). These cells also are thus parallelized with the "oil globules" of *Copepoda*. In such *Copepoda* as *Cyclops* and *Canthocamptus*, which appear to have no differentiated heart, there are always present drops of colored fluid, which are most numerous in well-fed and pregnant specimens. These drops occupy the same relative position as the blood globules of other *Crustacea*, i. e., they lie within a very thin membrane corresponding to the vascular walls of other animals. This membrane, in general, invests the alimentary canal, as can be very readily seen in the abdomen, where it incloses a considerable space about the intestine, which is filled with fluid, investing more or less completely the muscles

and other organs. As there is no rapid circulation of blood, these "oil drops" are comparatively stationary, and yet are moved slowly by the constant contraction of the walls of the alimentary canal, which, in the anterior part, or stomach, are thick and glandular, while in the abdomen they seem to be more fitted for respiratory function.

The above arrangement in *Cyclops* is correlated with its compact habit and thick carapace, and forms a simple starting-point for the study of the circulatory system in arthropods. It seems that the walls of the membranous blood cavity are themselves also, in places, furnished with muscles, so that the fluid is not dependent entirely on the vermiform or the peristaltic motions of the intestine for its escape from stagnation. If this be correct, we here have an indication of the origin of the central organ of the circulatory system.

But to return to *Daphnia*, the heart lies in the dorsal region over the intestine, upon which it may be said to ride, as it were, astride, though, as we shall see, it is separated from the intestine by other organs. In *Eurycercus* this is most evident, as here the heart is more obviously bifurcate.

The heart and circulation in *Daphnia* has been described more or less at length by many authors, in particular Claus ('76) and Gruithuisen (the work of this author I have not seen), while Weismann ('74) describes the heart of *Leptodora*, and Claus ('77) that of the *Polyphemidæ*. Other authors, except G. O. Sars, who elucidates some points in the circulation of blood in *Sida*, seem to have added little or nothing to our knowledge of this interesting subject.

As already often described, the heart occupies a place in a definite space—the pericardial chamber—the summit of which is the dorsal shield, which, we believe, should be distinguished from the remainder of the so-called cephalic shield. It is usual to describe the shell of *Daphnia* as consisting of a bivalve posterior portion or ormostegite, and a simple anterior cephalostegite; but it seems much more proper to consider that portion of the shell which covers the pericardial space and is the point of attachment of the powerful muscles of the abdomen and of the membranous walls of the pericardium as a distinct portion of the carapace, as it often evidently appears through the presence of a distinct suture, or, in its absence, through the peculiar sculpture of the shell. In such case it might also be proper to distinguish two regions on the lateral appendages of this dorsal shield, an upper and a lower, separated by the more or less obvious line extending from the union of the lateral lines of the dorsal and cephalic shield in nearly a straight line toward the posterior portion of the shell, and indicating the insertion of the muscles which move the feet and post-abdomen. The lateral walls of the pericardial space are the

shell walls themselves, and the floor is formed by a membrane supported on, and investing in part, the strong muscles which connect the abdomen with the upper anterior part of the dorsal plate. Thus a space is left between the pericardium and the intestine which is occupied by a special blood sinus leading toward the posterior and lower part of the abdomen. The posterior wall of the space is formed by a chitinous partition which bounds the brood space, or its homologue, and is connected by chitinous processes (stutzbalken) with the outer skeleton. The anterior, on the other hand, is only bounded by the supporting ligaments of the abdomen above described and membranous partitions. As usually described, the heart lies suspended in the cavity thus defined by slender muscular threads, more or less like those of the heart of *Corethra* larvæ and the like; and such seems to be the case at first, but a more careful study shows that this is far from correct. On the contrary, the chief supports of the heart are membranes which, seen in cross-section with the attached grains or blood globules, assume the appearance of exceedingly slender structureless threads. The action of re-agents indicates that these supposed threads are not muscles, but composed of connective tissue; while by changing the focus the sharpness of the line is frequently not altered, but *its relative position is changed*,—a simple test which often serves to dispel an illusion of this sort. That there are some threads of the character above mentioned is not to be doubted, as in connection with the valves of the heart; but the proper support of the heart is found in the membranes which invest it in part, and are reflected upon the walls of the shell and, anteriorly, of the intestine. It is not yet possible to fully describe the insertion of these tissues, as there is so large a number, especially about the anterior opening, where they lie in all directions and at all angles, and are so transparent that only their vertical sections appear as dark lines. Thus the same membrane appears and disappears, only to re-appear in a different position, where it might be readily taken for a distinct membrane. In general, however, I hope to make no serious error in the following summary. Before going into detail, however, it will be necessary to consider the intimate structure of the heart, as well as its general shape and position. (See Plate LI.)

The general shape is that of an irregular oval with the greatest convexity posterior (*Daphnia, etc.*), or it may be strongly bifid and thus somewhat Y-shaped (*Eurycercus, etc.*). It is held in position in the pericardial cavity by the membranes above alluded to, to which it is attached at definite points, the principal of which are two slight enlargements on the lower posterior portion, which are in part opposed to each other and also to a superior posterior point of insertion.

All three of these points are thus held in relation with the shell with which the attached membrane is connected on either side below and above. The membrane then extends part way along the heart wall towards the anterior and is then reflected to the shell wall. The result of this is that the pericardial space is an angular cavity opening in front. It would seem as though the membrane attaching the heart were identical with that lining the cavity itself. The heart proper is obviously composed of series of muscular elements, which are considered as simple cells by Claus, and which in young individuals show very distinct nuclei of comparatively large size. These are arranged like the meridian lines of a globe, uniting above and below, thus forming the most effective apparatus possible for contracting the heart. In the smaller *Daphnidæ*, as stated by Claus, there seems to be but a single layer of muscular rays, but in *D. schæfferi* and *Simocephalus* I have repeatedly satisfied myself that some of the longitudinal rays sink below the others and form a series of longitudinal muscles, as stated by earlier writers. These are furnished with a nucleus which is frequently more or less external, appearing like a spherical appendage. In *Leptodora* Weismann has shown the heart to consist primarily of a membrane of connective tissue, upon which the muscular fibers or cells sit in somewhat the same position as in *Daphnia*, except that there is not the same regularity in the arrangement. There are many considerations which would lead us to expect the same structure in *Daphnia*, though it is not yet demonstrated; and the structure of the anterior opening seems to point in the same direction. At any rate there is a close connection between the muscular and connective parts of the heart. We have, then, in the heart of *Daphnia* a highly developed apparatus for closing it, but apparently none for its opening. This certainly is not accomplished by the few fibers which connect the heart with the shell, the very contractility of which is doubtful. Nay, more, these are insufficient even to hold it in its place in the cavity. Still less can we assume that the heart, from any inherent power, can open itself. This must be explained by the operation of two factors which are interdependent, i. e., the elasticity of the supporting membranes and the unequal pressure of the blood in different parts of the body. 1. The membranes which support the heart are attached not at right angles, but, on the contrary, in a direction more nearly parallel to the walls of the heart, and thus whatever elasticity they possess is greatly increased; and the diminishing of the size of the heart draws these membranes out of their position at the expense of their elasticity, which tends to restore them to their original position when the pressure is removed, in the same way a drumhead returns after a blow to its normal position. This factor is, how-

ever, only operative so long as the whole system of membranes to which these belong is distended with fluid. If this blood cavity be punctured, the fluid flows out and the heart shrivels. It may continue to beat for some time, but it will be seen that the effort consists simply in a vigorous contraction which is followed by no perceptible enlargement. 2. After the systole the blood of the heart is forced toward the head, whence it is prevented from re-entering the pericardial space directly by the valves and the membrane inclosing the arterial blood. The pressure is therefore increased in all parts of the system except the pericardial chamber, where it is greatly diminished. The membranes supporting the heart are thus unusually tense, and the muscular effort having ceased, the walls of the heart are distended, and blood flows in in the direction of the least resistance through the two lateral openings or ventral valves of the heart. The contraction of the heart during the systole is not simultaneous in different parts, but begins by the contraction of the posterior part where, being nearly free, the motion is more marked. At the close of the systole the heart is irregularly contracted, the points of attachment above described being more distended than the remaining portions. The anterior of the heart is rendered very difficult to study by the fact that its opening is covered by the muscles of the mandibles and obscured by the many supporting and vibrating membranes alluded to.

It is, however, suspended by two folds of membrane which I have been inclined at times to believe blood-vessels through appearances resulting from the confused currents flowing about them. The upper margin is also attached by a pair of cords directly to the superior part of the shell. The anterior opening or arterial valve is most perplexing, and the following description which applies only to *Daphnia schæfferi* must be subject to some doubt. It appears, however, that it has been in a measure misunderstood by previous writers, and namely by Claus, who compares it with that of *Leptodora*, which, if correctly described by Weismann, is not at all identical in form, but quite comparable with one of the sides or lips of the venous opening. It does not seem to be connected by a thread, as stated for *Leptodora*, with the aortal bulb, for in reality there is no aortal bulb; the heart simply is connected with the system of membranes which more or less inclose the system. The floor of the so-called aortal space is a membrane which separates the outflowing stream from a current which flows toward the abdomen and passes directly under the arterial opening, so that it appears as though there was a stream entering the heart from before as well as at the sides; the arterial opening being nearer the dorsal part of the heart than is naturally expected, and the slight enlargements at the attachment of the supporting membrane

favoring the impression that there is here a veritable opening. The outflowing blood stream is bounded at first by the membrane above mentioned, which is farther on reflexed onto the shell and intestine so that the streams in the head flowing just under the shell are separated from the deep dorsal stream flowing from the heart.* This main current passes to the region of the eye between the horns of the cœca of the alimentary canal, and thence beneath the stomach, and here divides, part becoming external and a deeper part passing under the intestine, thence in front of the heart, flows into the deep sinus which, as before said, passes beneath this organ. Other portions of the returning stream flow around the angle of the union of the head and body and constitute a stream just above the feet in which the current flows vigorously.

Yet other portions flow into the region of the shell gland and are united with blood which here passes through the numerous sinuses described by Claus ('75) as surrounding this organ, and thence flows into the abdomen, uniting with the other two streams. A part also of the current in the head flows into the antennæ where it follows a deep course through the basal joint in which the corpuscles may be seen to emerge to the surface from two points where are spaces between the powerful muscles, the first being near the base and the second near the extremity of this joint, and then to return and join the superficial current.

The corpuscles appear to enter the rami very rarely if at all. That part of the superficial stream which reaches the interior of the pericardial chamber passes between the muscles of antennæ and jaws, and seems to find its way into the great current beneath the heart, though I have also thought to have seen it flow directly into the pericardial space as the lateral superficial streams do. That part of the superficial stream which reaches the posterior margin of the shell returns through a canal formed by the walls of the shell and the brood space, between the "stutzbalken" of which the blood corpuscles can be seen to glide more rapidly than in the free lateral spaces.

Lastly, it only remains to follow the fortune of the strong stream flowing along the neutral surface of the abdomen. The strong current flowing beneath the heart enters a broad sinus which lies over the intestine and extends for over a third of its length, where its walls unite with the surface of the intestine above and thus open downward on either side.

The stream thus directed flows toward the openings of the base of the feet. The structure of the branchiæ has not yet been clearly de-

* In *Pasithea rectirostris* this septum is easily seen as a swaying membrane, which near the eye is reflexed to the top of the shell.

scribed. Instead of nearly spherical or oval chambers they are really tubes which connect on one hand with the opening above, and below with the general cavity of the limb, whence the blood returns to the abdomen. The current is very rapid through these tubes. The blood having been returned to the abdomen, courses in the well-known manner through the post abdomen and flows over the intestine, thence over the back flowing stream to the posterior lower opening of the pericardial chamber.

The study of the actions of the heart is rendered more difficult by the fact that in order to secure the greatest possible transparency, the living animal must be covered and a little pressure applied, which is frequently attended with abnormal variations of the circulation. In particular, if the usual exit of the blood be stopped by the cœca of the intestine, as is frequently the case, the operation of the heart may be reversed, when a vigorous stream may be seen to enter the arterial opening and emerge from the ventricles. This process would be impossible if the anterior valve were as described by Claus and Weismann; while being really more like the venous valves, it is easily and frequently permitted. The current of the blood in this case stagnates except near the heart.

The rapidity of the pulsations of the heart varies with age and condition of rest or motion.

In *D. schafferi* this variation may range from about 150 per minute to perhaps 250, 200 being probably a fair average. In a young *Simocephalus* I have observed a heart beat 300 times in a minute. Again, in a specimen of *D. schafferi* at rest the heart was beating 170, but during the spasmodic motion of feet and antennæ the pulse rose to over 200.

GENUS MOINA Baird.

The systematic position of this genus has been the theme of some discussion, it being claimed, with good reason, that there are many resemblances to the *Lyncodaphnidæ* (P. E. Mueller considers it a transition to the *Bosminidæ* and *Lyncodaphnidæ*); on the other hand, Leydig and Kurz regard it more closely allied to the *Sididæ*, with equally good reason. The long antennæ, long narrow antennules and many peculiarities in form, etc., suggest the macrothroid crustaceans; the extended abdomen and especially the location of the male seminal opening are like *Daphnella*, which *Moina* resembles in motion and habit very strikingly. The absence of the pigment fleck is no more a characteristic of the *Sididæ* than of other groups. After all has been said, the immediate affinities of the genus are acknowledged to be with the *Daphnidæ*.

The true place of the genus, as it appears to the writer, was hinted at by Birge (*Notes on Cladocera*). *Monia* seems to be the pivotal point of the *Cladocera*, at least of the families above mentioned. Without going into phylogenetic speculation, it is suggestive that this genus can and does by preference live in very impure water, and may therefore have had an early origin. From *Moina* diverges the stem of the *Daphnidæ* by way of *Ceriodaphnia*, *Simocephalus* and *Daphnia*. These two latter genera are intimately connected by *Simocephalus daphnoides* Herrick. *Scapholeberis* is connected with *Ceriodaphnia* through *S. angulata* Herrick. The *Sididæ* seem to diveege by the way of *Daphnella*, through which by means of *Pseudo-sida* the genus *Sida* is reached, and finally *Limnosida*, *Latona* and *Holopedium*. The relationships of the curious *Polyphemidæ* are less evident.

The *Lyncodaphnidæ* make an easy transition to the *Lynceids* proper, while the *Bosminidæ* are still quite isolated, but are suggested by *Macrothrix pauper*. The fact that *Moina* stands thus related to radiating groups is simply suggestive, but it is suggestive of its possible antiquity and synthetic character.

The three species of this genus stand very poorly distinguished from one another and their specific validity may be doubted.

The most exhaustive study of the embryology of the *Cladocera* was based on *Moina* (Grobben '79).

The genus is characterized by Weismann and Gruber ('80) about as follows:

Head prone; separated by a depression from the thorax; fornices obscure; rostrum none; pigment fleck absent; antennules of the female large, movable, furnished with a sensitive seta near the middle, flagelliform; antennules of the male very large, hooked at the end. The setæ of the antennæ are all ciliate; the tri-articulate ramus with five setæ; posterior margin of the valves thicker in the median line; caudal setæ very large, about twice in the length of the animal; anus above the claws; feet of the first pair of the male with a strong hook.

Weismann has shown that both summer and winter eggs originate from groups of four cells, one of which only is transformed into the egg, the remaining three serving simply as a supply of nourishment for the egg, which absorbs it directly. Both eggs and nutrient cells develop from the epithelium of the termination of the ovary. The summer eggs have less yolk than the winter brood, and the yolk is bluish in the summer eggs and deep red in the winter eggs of *Moina rectirostris;* while in *M. paradoxa* the summer eggs have yellow and the winter set snow-white yolk. There are never more than two winter eggs in any of the *Daphnidæ*, but there are as many as twenty summer eggs in some cases in *Moina*. In *M. rectirostris* only one winter egg is

produced, which is one of the best distinctions of the species, as this is, perhaps, the only case (Weismann '76-'79). The first generation, springing from the winter eggs (impregnated eggs), is composed solely of females which reproduce parthenogenetically; the second brood contains sexual males and females, thus completing the cyclus.

To the above, which is reproduced with a few verbal changes from the first edition, it may be added that the interesting genus *Moinadaphnia*, found in Alabama, makes the transition toward the genus *Daphnia* and its immediate allies complete. It should not be overlooked that there are several forms of *Moina* which have the anastomosing striæ upon the shell which is characteristic of *Simocephalus*, while the ephippium has the characteristic hexagonal marking of *Ceriodaphnia*. The synonomy of the genus is uncertain, and there is no doubt that several authors have confused more than one species under a single name.

The following artificial key may assist in placing the species, but should not be too mechanically relied upon.

KEY TO THE GENUS MOINA.

I. Shell not sculptured or simply dotted.
  A. Spines of the abdomen fewer than nine. . . **micrura** [not described.]
  B. Spines of the abdomen nine or more.
    a. Claw with a basal series of strong spines externally.
      * Ephippium with two eggs, shell reticulate. . . **brachiata,** 162
      ** Ephippium with one egg, shell smooth. . . **rectirostris,** 163
    b. Claw with a basal series of fine hairs externally and a continuous series of the like internally.
      fischeri, 165; **paradoxa,** 164

II. Shell more or less covered by anastomosing striæ.
  A. Claws smooth. . . . . **propinqua,** 165
  B. Claws with teeth. . . . . **lilljeborgi** [not described in the text.]

[Not noticed in the key: **azorica,** 165; **salina,** 166; **banffyi,** 166]

Moina brachiata Jurine.

PLATES XXXIX, FIGS. 5-8; XLIII, FIGS. 1, 2.

Jurine '20 (Monoculus brachiatus); Straus-Durckheim '19-'20 (Daphnia macrocopus); Zaddach '44 (Daphnia brachiata); Lievin '48 (Daphnia brachiata); Baird '50; Leydig '60 (Daphnia brachiata); P. E. Mueller '68; Uljanin '75[1]; Kurz, 74; Hellich '77; Schoedler '77; Birge '78 and '91; Herrick '82 and '84; Richard '88[1]; Lund '70-'71.

It is quite certain that the above bibliography includes several instances where the name *M. brachiata* is applied to other species or to include several species, but it seems best to place all in evidence.

The description given by Hellich is the most full at our disposal and runs about as follows: Body robust, untransparent greenish in color. The head depressed and broadly and deeply excavated above the eye. Lower angle of head with the front strongly arched. Eyes with many lenses; pigment fleck absent. Antennules springing from the middle of the lower margin of the head, slightly enlarged at the middle, covered with short hairs, with one lateral flagellum, as long as the head. The antennæ reflexed do not attain the posterior margin of the shell and are hairy. Shell margin short-spined in front and armed with fine spines to the posterior lower angle. Shell faintly reticulate. Post abdomen large, lateral spines ten to eleven, the first being bifid. Claws strongly curved, with a series of eight or nine strong teeth at the base and a continuous series inwardly. Length 1.3 to 1.4 mm. Male smaller, head extended. Antennules affixed nearer the front, longer than the head, flexed at the middle, armed at the end with four cleft claws and at the middle externally with three short bristles. Unfortunately Hellich does not describe the first foot of the male, though P. E. Mueller figures it as devoid of the elongate flagellum characteristic of *M. paradoxa*.

* **Moina rectirostris** Jurine.

PLATES XXXIX, FIGS. 1-4; XLI, FIGS. 2, 5, 8, 10, 11.

Jurine '20 (Monoculus rectirostris); Fischer '49 (Daphnia rectirostris); Leydig '60 (Daphnia rectirostris); Baird '50; Fric '72[1] (Daphnia rectirostris); Kurz '74; Weismann '77; Hellich '77; Schoedler '77; Herrick '84.

From the preceding, which it too closely resembles, this species differs in the fact that the shell has no trace of reticular marking, the ephippium has but a single ova horizontally placed, while *M. brachiata* has two in a vertical position. The post-abdomen has twelve to fourteen teeth as against nine or ten for *M. brachiata*. The free caudal margin of the abdomen is hairy. The shell margins below are armed with distant and short teeth. Hellich thinks Kurz identified this species with the last. With the above this species agrees in the form of the head and antennæ and nearly all other characters.

As for the American forms, it is quite possible that we shall eventually be enabled to distinguish several varieties of the *brachiata rectirostris* type, but very careful study of local and seasonal influences will be necessary to give to such distinctions any value as specific characters. That considerable variation does occur is beyond question. We may recognize two types which do not correspond fully with the two European varieties.

VARIETY A—Length 1.1 to 1.2 mm., head 0.37 mm., depth of head 0.40. Head slightly angled above the eye; antennules short (not much

more than half as long as the height of the head), hairy, straight, spindle-shaped, inserted somewhat behind the middle of the lower margin of the head and not in a special depression, flagellum one-third from base 0.21 mm. long. Body subject to great variation, but always much wider than the head. Lower shell margins sparsely spined to near the posterior angle. Abdomen slender, with several teeth in front of the claws. Claws slightly curved with a basal external series of strong teeth and a continuous inner series of fine spines. Lateral abdominal spines twelve or thirteen. Posterior margin above the anus slightly hairy. Ephippium with one egg, ephippial female with an abdominal process. Shell with elongate hexagonal markings.

VARIETY B—Proportions exhibited by the following measurements: Length, 1.1 mm.; length of head 0.41 mm., height of head 0.46mm. The head is strongly depressed, excavated above the eye. Antennules slender, long, hairy, attached far from the eye at a sharp angle of the inferior margin, flagellum nearer the middle than the preceding. Antennæ very hairy. Body less robust than the preceding, ventral margin sparsely hairy to a point some distance from the posterior angle, thence to the upper posterior angle armed with minute closely set spinules or teeth. Abdomen slender, without the numerous small teeth above the claws on the front margin, claws with about ten strong basal teeth and a continuous inner series. Lateral abdominal spines ten or twelve. In neither variety have we seen any other markings than the point-like elevations scattered over the shell except upon the ephippium. Almost the only reliable difference between these varieties seems to be in the form and insertion of the antennules and the outline of the head.

* **Moina paradoxa** Weismann.

PLATES XXXIX, FIG. 9; XL; XLI, FIGS. 1, 3, 4, 6, 7, 9.

Weismann '77; Gruber and Weismann '80; Schoedler '77; Hellich '77 (fischeri); Herrick '84; Moniez '88 (azorica).

This species may be distinguished from the preceding by the fact that the head is short and not excavated above the eye, the teeth of the terminal claws are reduced to bristles in two series, the first foot of the male has a long flagellum, longer than the whole member, the male antennule is very long and flexed at about the middle, and the ephippium contains two winter eggs.

The mature summer female is almost monstrously deformed by the multitude of young in the brood sac, which swell that cavity into a great sub-spherical sac extending in all directions beyond the ordi-

nary limits of the shell. The ephippial female retains more of the normal proportion, but the dorsal half of each valve is mostly transformed, by the development of very pronounced reticular markings and thickening, into a two-valved, pod-like case for two perpendicularly disposed winter ova. The male is elongate, with the head much produced forward and remarkably developed antennules and feet of the first pair. The former are sharply flexed near the middle at the insertion of the muscle, at which point is one short spine and a slender flagellum. At the end are three curved claws and the sensory filaments. The inner branch of the first foot is, as usual, modified to form a strong hook, while the outer ramus has a very long curved flagellum which protrudes beyond the shell and bears a terminal hook. The antennule of the female is attached nearer the eye than the base of the labrum, but has no pronounced depression; it is nearly cylindrical and but slightly curved, very hairy, and its flagellum is at its basal one-third. The antennæ are strong and densely ciliate throughout. The whole ventral margin of the shell is armed with distant setæ. The abdomen is rather short, the claws being short and slightly curved and bearing a short series of fine spines externally at the base and a continuous series of spinules internally. The lateral spines are nine to ten and ciliate. The dorsal part of the posterior margin is ornamented with clustered hairs.

Moina fischeri Hellich is undoubtedly the present species, but there seems to be no way to settle the priority of names.

Length 1.03 mm.; length of head 0.35 mm., antennule 0.27 mm., height of summer female 1.08 mm., length of male antenna 0.04 mm., length of ephippium 0.6 mm.

It may be noticed in passing that the generic distinction claimed for *Moina*, based on the absence of the process for occluding the brood sac, is not absolute, for we have seen in the case of gravid females of *M. paradoxa* a small process, and Sars also mentions one in *M. propinqua*. This prepares us to find it well developed in the next of kin, *Moinadaphnia*. Matile states that this species was first described by Hudendorff ('76) as *Moina flagellata*, but I am not prepared to investigate the question.

Moina salina Stephanow was regarded by him as a saline modification or variety of *M. rectirostris*.

The description of *Moina azorica*, as given by Moniez, is as follows:

"Chez sette espèce, la tête, dans les deux sexes, est arrondie, sans depression; l'antenne du male est terminée non par des crochets, mais par des tentacules qui, sous l'influence de l'alcool, prennent une forme assez irreguliere et dont l'extremite s'invagine en doigt de gant; l'antenne port une soie unique a l'endroit de la courbure. Le fouet de la premiere patte du male est enorme, et mesure 5 fois la longuer de

l'article terminal, mesure a partir de l'extremite de la branchie; chez la femelle cette meme patte est charaterisee par l'une des soies, qui s'est transformee en un batonnet court et gros, cilie d'une façon particuliere. La conformation des autres pattes, dans les deux sexes, presente egalement des characteres speciaux, difficiles a exposer sans le secours du dessin on sans une longue description. La carapace est marquee de tubercules termines par des poils; les crochets dorsaux sont simples et limitent un large espece qui prend la configuration d'un cœur quand la coquille est etalee. Les crochets terminaux du post-abdomen portent au cote interne et vers leur base une plaque dentee, et ils sont surmontes d'une dent unique; ils n'ont pas de peigne. La femelle porte deux œufs dans son ephippium."

Daday mentions the following species, which are added provisionally:

Moina salina Stephanow.

Capite supra oculum impressione insigni, fornice indistincts; testa corporis fere quadrangulari, margine anteriore ac inferiore setis perpaucis; antennis in mare apice unguibus curvatis, majusculis 5; abdomine sine processu; cauda aculeis magnis 10 setosis armata, margine superiore tuberculis perparvis lateribusque setis minutis, in series transversales bositis; unguibus caudalibus sine spenarum serie pectiniformi margine anteriore processu dentiformi longe, usque ad medium setosis. Longit fem., 0.75 to 0.9 mm.; altit, 0.45 to 0.5 mm.

Moina banffyi Daday.

Testa capitis setis tecta; testa corporis fere quadrangulari, obtuse angulata, parte postica supra duos processus curvatos formanti; antennis primi peris abique ciliatis, laminis quadrangularibus obtectis; cauda apicem versus attenuata; unguibus caudalibus curvatis, setosis. Longit. fem., 0.9 to 15 mm.

GENUS MOINADAPHNIA Herrick. 1887.

Head strongly arched above, angled in front of the eye, somewhat beaked at the caudal end of the lower margin, near which are affixed the slender antennules. Body quadrate, as in *Daphnia*, but merely angled at the dorso-caudal angle. Post-abdomen elongate, armed as in *Moina*. Brood sac occluded by strong abdominal processes. Antennæ with a long unjointed spine from the apex of the last joint of the four-jointed ramus, otherwise as in *Moina*. The first member of this genus was found by L. R. King ('52 to '54) in New South Wales and named *Moina macleayii*. The figure and description were repeated by Schoedler ('77), but he does not suggest generic autonomy.

***Moinadaphnia alabamensis** Herrick.

PLATE XXXVI, FIGS. 7-10.

Herrick '87.

As suggested in the original paper, this species not only affords a needed transition between *Moina* and *Daphnia* but also forms a link

with the fauna of the southern hemisphere. The species is large compared with *Monia*, being 1.68 mm. long. The head is shaped much as in *Simocephalus*, being acutely rounded in front of the eye and provided with a distinct beak, near which the antennæ are attached. The eye is large and the fornix evident, as in *Daphnia*. The antennules are long and slender, little narrowed apically, armed with a flagellum at the basal third. Antennæ slender, segments narrow; apical segment of four-jointed ramus has in addition to the three geniculate setæ a very long spine representing the short thorn occupying that place in *Moina*, otherwise as in that genus. Body quadrangular, somewhat produced above at the posterior angle. Lower margin armed with short spines as in *Daphnia*. Abdomen slender, claw slightly curved and armed with a continuous series of small setæ. A short spine in front of the claw. Lateral spines as in *Moina*, twelve or more in number, the first being bifid. Dorsal part of abdomen with a long process for occluding the brood sac, also a blunt tuberosity caudad of it. The general habitus is like *Moina*, but in the form of the shell and many details it approaches *Daphnia*. The description of King's species is not full enough to make specific comparison possible, but of the generic relationship there can be no question. The most important diagnostic difference—that in the formula of the antennary spines—not fundamental but a mere matter of proportions.

GENUS CERIODAPHNIA Dana.

The genus *Ceriodaphnia* is the successor to *Moina*, which some species greatly resemble; the post-abdomen, however, is shorter and has a habitus resembling *Daphnia;* the antennæ are smaller and the shell is thick and coarsely reticulated.

Ceriodaphnia has the same general mode of life as *Moina*, living in muddy pools in late summer and bearing numerous broods which often greatly extend the brood cavity. The antennules are shorter but have a similar form; the male antennæ show a transition in the various species from forms adapted for prehension to such as are found in *Daphnia*. The brood cavity is closed by two ridges on the abdomen instead of one, as in *Moina*, or three, as in *Daphnia*.

The ephippium contains but a single ovum. In general, the form is oval or quadrate, angled but not spined posteriorly; head separated from the body by a deep depression; pigment fleck present; beak absent; antennules movable, rather short; antennæ with the three-jointed ramus with five setæ; first foot of the male with a hook or flagellum.

The members of this genus are danger signals from a hygienic point of view, for they frequent water containing decaying matter; as many as 1,400 were counted in a single quart of such water. The genus is particularly perplexing, as the varieties named seem to be hardly entitled to specific rank and are so similar as to require great care to properly distinguish.

The following artificial key, it is believed, will assist in placing the specimens which may be obtained in America. There seems no reason to doubt that our fauna is very similar to that of north Europe. Of the twelve species here enumerated at least one-third may be synonyms and others of the remainder are with difficulty distinguished.

KEY TO THE GENUS CERIODAPHNIA.

I. Head without a "horn."
  a. Shell irregularly striate. . . . . **megops,** 168
  b. Shell with hexagonal meshes.
    * Shell with doubly contoured markings.
      † Head broad, short. . . . . **pulchella,** 169
      †† Head narrowed, depressed.
        ‡ Antennules normal. . . . . **rotunda,** 169
        ‡‡ Antennules elongate. . . . . **alabamensis,** 170
    ** Shell simply marked.
      † Claws with teeth. . . . . **reticulata,** 170; **dentata,** 170
      †† Claws without teeth.
        ‡ Antennæ very long. . . . . **punctata,** 171
        ‡‡ Antennæ normal or short.
          ½ Post-abdomen broad. . **laticaudata.** 171; **consors,** 171
          ½½ Post-abdomen narrow.
            | Head not angled behind the eye. . **quadrangula,** 172
            || Head abruptly angled behind the eye. . . **scitula,** 172
    *** Shell opening pointed. . . . . **setosa,** 173
  c. Shell recticulate with rectangular meshes. . . . . **nitida,** 173
II. Head with a curved "horn." . . . . **cornuta,** 174

[Not noticed in the key: **asperata,** 173; **minuta,** 173; **textilis,** 173; **rotundata,** 173; **echinata,** 173]

* Ceriodaphnia megops Sars.

PLATE XLI, FIG. 20.

Birge '78 (cristata).

This species is one of the largest and most readily distinguished as well as rarest of the genus. Very characteristic is the fine anastomosing striation which breaks up into reticulation only near the shell margins. This species seems to form the transition toward *Simocephalus* with *Scapholeberis*, which, however, diverges along its own pecu-

liar track. The length is sometimes 1.0 mm. The head is obscurely angulated in front of the antennules, which are large. The antennules of the male are long and have hooked seta at the end.

The description of *Ceriodaphnia cristata* given by Birge would apply in almost every particular to *C. megops*, though he seemed to overlook the close conformity. The size is much less (0.7 mm.), and the post-abdomen seems more abruptly truncate; moreover the number of anal spines is less. The crest upon the dorsal margin may be the effect of prominences such as are described by P. E. Mueller; at any rate, in view of the fact that but few specimens were discovered, the suggestion lies near that *C. cristata* is the young or, at least, a reduced form of *C. megops*. Professor Birge writes that he now unites *cristata* with *C. megops*.

Found at Southampton, Mass.

Ceriodaphnia pulchella Sars.

PLATE XLI, FIGS. 14, 19.

Very much like *C. reticulata*, but smaller. Head large, turgid, and angled in front of the antennules, forming almost a right angle; fornices moderate; antennules rather large; shell oval, reticulated with double contour lines; post-abdomen of medium size, narrowed toward the end, slightly truncate, with about nine spines; terminal claws short, smooth. The flagellum of the male antennæ is but slightly hooked, 0.5 to 0.6 mm. long. This species is not certainly identified from America, though a form with smooth claws and small fornices occurs with *C. dentata* in some places.

Ceriodaphnia rotunda Straus.

PLATES XLI, FIGS. 12, 23; XLII, FIG. 1.

Daphnia rotunda—Straus, Baird.

As said by Kurz, this species is not easily mistaken; the small head (only paralleled by the following), the very evident reticulations and the broad abdomen give it a peculiar habitus which is unmistakable.

Head depressed, small, spiny below, not angulated; fornices prominent, thorned; body rotund, almost spined above; shell doubly reticulate; post-abdomen broad, with seven or eight anal spines; claws large, smooth. The male antennules are little larger than those of the female. I have not yet seen this species in America.

* Ceriodaphnia alabamensis Herrick.

PLATE XLII, FIG. 2.

(American Naturalist, May, 1883. Plate V, Figs. 11, 12.)

This species was seen but once and is insufficiently known. The body is elongate, quadrate, the shell reticulated with double contour lines, the head very small and produced downward below the eye, which is very small, the antennules are longer than in any other species, obviously two-jointed, with a lateral seta; the antennæ are very long; post-abdomen long and rather narrow, with the margins nearly parallel, truncate at the end, with over nine anal spines; claws smooth, abruptly truncate. My drawing represents a daphnia-like set of processes for closing the brood cavity. Length 1.0 mm.

Tuscaloosa, Ala.

* Ceriodaphnia reticulata Jurine.

PLATES XLI, FIGS. 15, 21; XLII, FIG. 3; XLIII, FIG. 3; XLIV, FIGS. 3, 4.

Monoculus reticulatus—Jurine.
Daphnia reticulata—Baird, Leydig.
Ceriodaphnia quadrangula—Schoedler.
Ceriodaphnia fischeri—Leydig, Schoedler, etc.

Head long, obscurely angled in front of the antennules; fornices very prominent; antennules small; post-abdomen of moderate size, rounded at the end, slightly tapering; about eight long anal teeth; terminal claws with a series of sharp spines at the base. The reticulations are sharp but simple. The flagellum of the male antennule is either straight or moderately curved. Kurz says that some varieties have the fornices blunt while others are sharp. I have seen only the blunt form, which is then much like the next.

[* Ceriodaphnia dentata Birge.]

This form differs from the above only in having the inside of the claws fringed with minute bristles (sometimes absent), the angle of the head being more marked and the fornices less prominent. It is difficult to say whether our Minnesota specimens most resemble this or the typical *C. reticulata* of Europe. They seem intermediate, some having fornices with an abrupt angle. It may be instructive to quote Kurz on the European *C. reticulata*: "Examples occur 0.8 to 0.9 mm. long, others on the contrary only 0.5 to 0.6 mm. long and combining with the smaller size some differential characters. In the larger variety I found the fornix obtuse, while in the smaller it extends in a sharp thorn directed upward and outward. In this small sub-species

the secondary teeth of the claws of the post-abdomen seemed to be absent, though in *C. reticulata* three to five are constantly present." Professor Birge now identifies this species with *C. reticulata*.

Ceriodaphnia punctata P. E. Mueller.

PLATE XLI, FIG. 13.

Head depressed, rounded at the end, not angulated, ornamented with minute spines within the hexagonal areas. Fornices slightly prominent, either smooth or spiny; antennules very long; shell rotund, reticulated; post-abdomen of medium size, width nearly uniform, truncate below at an obtuse angle; anal spines large, increasing toward the end; claws smooth. Length 0.7 to 0.9 mm.

Found as yet only in Scandinavia.

* **Ceriodaphnia laticaudata** P. E. Mueller.

PLATE XLI, FIG. 22.

Ceriodaphnia quadrangula—Sars (fide Mueller).
Ceriodaphnia consors—Birge.

Head small, depressed, rounded at the end, not angulated; fornices prominent; shell roundish, or sub-quadrangular, moderately reticulated, antennules rather large; post-abdomen broad, narrowed from the middle to the end; the nine or ten small anal spines nearly equal; claws large and smooth. In P. E. Mueller's time males unknown. Length 1.0 mm. Specimens 0.6 mm. long from Minnesota agree in most respects, but the reticulation is very marked and irregular and the terminal claws are pectinate. This form constitutes a transition to the next.

A species related to *C. laticaudata*, but only half the size, was found in Clarke's lake, a small but very deep pool, containing a fauna like that of the Great Lakes. The appearance is like the small form alluded to under that species, but the claws are smooth, the head is slender and strongly angled behind the eyes, and the antennules are of rather large size. The fornices are not very prominent. The shell is large-reticulate and the abdomen is large and obliquely truncate, the anal teeth being very large and strongly curved. The only individuals seen were ephippial females measuring 0.55 mm. This may be

* **Ceriodaphnia consors** Birge.

PLATES XLII, FIG. 4; XLIV, FIGS. 5, 6.

This differs from *C. laticaudata* in one or two points, being about one-half the size and having fewer caudal teeth. Birge says the abdo-

men is broad and obliquely truncate. The difference between being obliquely truncate and narrowed at the end in some circumstances disappears, so that really this species seems quite close to *laticaudata*.

Found in Madison, Wis.

Ceriodaphnia quadrangula Mueller.

PLATE XLI, FIGS. 16-18.

Daphnia quadrangula—O. F. Mueller.
Daphnia reticulata—Baird.

Head depressed, rounded at the end, only slightly angled; fornices prominent, antennules large; post-abdomen narrow, of equal width for the lower half, rounded at the end, with about eight small spines; claws smooth, length about 0.6 mm. This species resembles a smooth-clawed *D. reticulata*.

* Ceriodaphnia scitula Herrick.

PLATES XLII, FIGS. 5-8; XLIV, FIGS. 1, 2; XLV, FIG. 1.

One of the most abundant species of *Ceriodaphnia* in Minnesota is a large form much resembling *C. quadrangula*. The post-abdomen is exactly as in *C. reticulata* or *C. dentata*, which latter it resembles in having a sharp angulation in front of the antennules. The shell is oblong and heavily marked with minute, regular hexagonal lining; the upper angle is rather sharp. The head is closely appressed, the fornices are prominent and abruptly truncate at the tip, the eye is small, the pigment fleck also small; antennules short. The post-abdomen is of moderate size, narrowed toward the end and armed with about ten powerful curved spines; the terminal claw itself is large and curved, armed only with fine spines extending down the entire inner side. The size is 0.8 to 1.0 mm.; color pinkish, opaque; antennæ, especially, often bright pink. Male 0.6 mm.; flagellum of the male antennæ long; sensory filaments lateral, also one anterior, lateral flagellum.

Distinguished from *C. quadrangula* by the prominent fornices, large anal spines, small reticulations, form of head and larger size.

A small variety resembling the above very closely is the commonest form in our larger lakes; the reticulation is commonly larger but less distinct, the head is depressed and narrowed, with a sinuous upper outline. The fornices are prominent and the form of the post-abdomen is exactly as in the last. The spines of the post-abdomen are very long and seated on small eminences. The length hardly exceeds 0.55 mm. The claw is densely ciliated, but not spined; these

smaller forms have but few eggs (two). The young have a thorn on the angle of the fornices. Plate XLV, fig. 1, represents the ephippial female of this species. There seems no reason to doubt that this is only a variety of *C. scitula*. The small form of *C. reticulata* mentioned by Kurz might be referred here, while the larger form with less prominent fornices is not so different from the American *C. dentata*.

Ceriodaphnia nitida Schoedler.

Ceriodaphnia quadrangula—Leydig.

This species seems to be characterized by the quadrangular form of the meshes of the shell-markings and the presence of teeth upon the claws. Probably invalid.

Ceriodaphnia asperata and *C. minuta* of Moniez have remained unknown to me. Cf. Note sur des Ostracodes, Cladoceres, et Hydrachnides observes en Normandie. *Bul. d'etudes scientifiques de Paris, 1887.*

Ceriodaphnia textilis Dana is not sufficiently fully figured to allow of a suggestion as to its affinities.

Daphnia rotundata Say is very probably a member of this genus, though the description is hardly intelligible. "Body rounded behind; upper antennæ three-branched, a small spine above at the joints; lower five-banched; color white. Length 0.5mm." It is probable that we should read "upper branch of antennæ with three setæ," etc., in which case we may identify the above with *Chydorus* or the like.

Ceriodaphnia setosa Matile.

Matile '90.

Body spherical, resembling *C. rotunda* and *C. laticaudata*, brownish red. Head small, depressed. Front uniformly rounded. A deep depression between head and body. Fornix moderate, spiny. Head and body ornamented with polygonal meshes from every angle of which springs a spine perpendicular to the surface. Antennæ very short. Antennules rather long, lateral seta nearer the base than the tip. Post-abdomen large, gradually narrowed toward the end. Anal teeth seven or eight and nearly equal. Claw armed with a series of fine cilia. Eye large. Macula small. Length 0.42 to 0.57 mm.; heighth 0.27 to 0.36 mm.

It is probable that this is identical with *Ceriodaphnia echinata* Moniez ('87, p. 512), but there are minor differences and the problem must be left open.

Ceriodaphnia cornuta Sars.

Sars '85.

This interesting species furnishes further evidence of the close relation between *Ceriodaphnia* and *Scapholeberis* by the possession of a frontal spine or "horn." Head much depressed, with frontal part slightly dilated. A process arises directly cephalad of the eye, another forming a beak. Carapace broadly oval, tumid, with a bifid caudal projection from the upper angle. Whole shell distinctly reticulate with polygonal markings. Antennules short, fusiform, lateral seta near the middle. Two distinct abdominal processes. Anal spines about eight. Claw without basal teeth. Length 0.6 mm. The form resembles *C. quadrangula*. The fornices are acute.

GENUS SCAPHOLEBERIS.

The genus *Scapholeberis* stands rather closely related to *Ceriodaphnia*, from which it is at once distinguished by the angled or spined lower posterior angle of the shell. The head is rather clumsy, and the continuation of the fornices runs toward the apex of the incurved beak, which commonly lies within the valves of the shell. The lower anterior angle has a prominence and there is a basin-shaped area inclosing the base of the antennæ, part of which lies on the shell and part on the head. This area is more strongly lined or reticulated than the rest of the shell. The lower margin is straight and terminates, in most forms, in a long scythe-shaped spine which is directed backward. The shell itself is usually indistinctly reticulate or unmarked, and commonly is deep colored. The post-abdomen is very like *Ceriodaphnia* or more as in *Simocephalus;* the anal spines are few and the older specimens have more than the young; the place at which additional spines are to appear is marked by prominences. The eye is of moderate size, the pigment fleck rather small and the antennules short and hidden by the beak. The antennæ are of small size and generally dark colored. The ephippium contains but one egg; the males do not have altered antennæ or feet. The sexual periods fall in early summer and in autumn, according to Weismann; the males appear but sparingly. The species *S. mucronata* is very abundant everywhere, while the others are less frequently seen.

* **Scapholeberis mucronata** Mueller.

PLATES XLIII, FIGS. 4-7; XLV, FIG. 5.

Daphnia mucronata—Mueller, Lievin, Lilljeborg, Fischer, Leydig, Baird, Herrick.

This well-known species with rather short spines below is found

abundantly everywhere. In this country at least it is characterized by a dark color. The head is large, rounded in front of the large eye, serrate below and extending posteriorly into a roundish beak, back of which are the short antennules. The fornices are very short and rounded; a line connects the fornices with the beak by a sudden deflection downward; it sets off the area which forms a part of the basin of the antennæ. A second line springing from just above the termination of the fornices passes over the eye by a broad curve. The postabdomen is truncate and bears beside the terminal claws four or more spines which rapidly decrease in size. The claws are minutely spined; the spines on the shell are of variable length, but do not exceed one-fourth the length of the remainder of the lower margin. This species ranges over all Europe and eastern United States.

Length 0.6 to 0.8 mm.

Scapholeberis cornuta Schoedler.

PLATE XLV, FIG. 6.

Monoculus bispinosus—De Geer.
Daphnia mucronata var. acute rostrata—Baird.
Scapholeberis mucronata var. fronte cornuta—P. E. Mueller.

This species differs from the above only in having a sharp curved horn on the head in front of the eye. The use of this appendage can only be conjectured; but it may be that, like the curved beak of *Ripophilus*, it serves to clear away rubbish in the filth in which these animals frequently live. This form, be it variety or species, is not known in America.

* **Scapholeberis armata** Herrick.

PLATE XLII, FIGS. 10, 11.

Scapholeberis mucronata var. armata—Herrick.

A very beautiful and unique species, which possesses the extreme development of the peculiarities of the genus. The head is shaped very much as in the previous species, the fornix is squarish, the basin for the antennæ is small. The upper lines from the fornix meet behind the eye; the form of the shell is as in the above, but the spines upon the lower margin are longer. The scythe-like spine on the lower angles of the valves is extremely long, falling little short, in extreme cases, of being as long as the entire lower margin, in others about one-half as large. There are the usual lines parallel to the lower edge of the shell. The specimens having the longest spines were found in fresh water about Mobile, Ala., but the species occurs in Minnesota and intermediate points, though sparingly. Probably the earlier plan of regarding this as a variety of *S. mucronata* is nearer correct.

***Scapholeberis aurita** Fischer.

Daphnia aurita—Fischer.
Scapholeberis nasuta—Birge.

Form much as in the last, head shorter, "prolonged into a rather sharp beak, at whose apex the continuations of the fornices unite. The beak does not project downward as in *S. mucronata*, but backward, and in its natural position lies between the valves." The usual reticulated and lined areas are present and the balance of the shell is covered with "small pointed projections." "The antennules are much larger than in *S. mucronata*, though they do not project beyond the rostrum." The pigment fleck is long and large; the post-abdomen is much as in the preceding species; the terminal claws have several fine teeth. The males have the opening of the vas deferens close behind the terminal claws; mucro short and blunt, length 1.0 mm. This species is very near the next, but differs in several particulars. It forms the transition to the next, which is the extreme of the genus in a direction converse to that pursued by the *S. armata*.

***Scapholeberis angulata** Herrick.

PLATES XLII, FIGS. 9, 9a; XLV, FIGS. 7, 7a.

Herrick '83.

Form as in the above, but comparatively larger; valves quadrangular, anterior margin strongly arched; head short, only slightly concave below the eyes: the beak is as in *S. nasuta*, but seems to be directed more nearly directly downward than in that species. The antennules are long and resemble those of *Simocephalus*. The pigment fleck is square and rather large; the antennæ are of the usual size. The reticulated areas are as in the other species. The post-abdomen is more as in *Daphnia*, not so squarely truncate and with five to seven large teeth; the first foot has one elongated jointed seta; the posterior angle of the shell has no spine, at most there is a somewhat prominent acute angle, the inner shell layer is armed at this point with some elongated teeth as in the corresponding situation in *Simocephalus*. On the whole, there is a similarity to that genus in this as well as in the previous species. *S. nasuta* has a short spine and elongated pigment fleck, the present species has a squarish but rather large fleck and no spine; the post-abdomen has a greater number of spines than any other species. South of Tennessee river, in Alabama and Mississippi.

The species of this genus are predominatingly American, four out five being found in the United States; the fifth, moreover, is more often regarded a variety of one of the others; in fact, the absence of

S. cornuta from America is one of the most important supports of the specific independence of the two forms. All the species delight in disporting themselves near the surface in sunny weather.

GENUS SIMOCEPHALUS.

Although a very well circumscribed group, this genus passes into the next rather directly by means of *S. macrothrixoides*. The connection on the other hand seems to be by the way of *Scapholeberis*, though there is a rather broad separation between even *Scapholeberis angulata* and any known *Simocephalus*. The enlarged spines near the angle of the shell and the form of the antennules as well as some other points, show a transition through that species toward the present genus. The general form is quadrate with the lower posterior margin sinuate; in young specimens the shell is nearly a perfect rectangle. The upper margin is produced more or less at the point of union with the free posterior margin, and the shell is either arched or very abruptly angled above the prominence in old females. The head is produced into a projection at the eye, while the beak proper is between the anterior margins of the valves; the pigment fleck is rather large and variously shaped. The fornices are larger than in *Scapholeberis* and extend to the front of the head over the eyes; the antennules have a lateral flagellum which is large and lance-shaped. The post-abdomen varies very little in shape; it is truncate and excavated below and very broad. The anal teeth are few, large, curved, pectinate; the claws are straightish and pectinate or spined; the labrum is shaped as in *Daphnia;* the anterior part of the stomach has the usual cœca.

The members of this genus are among the most abundant and conspicuous of the family and are more persistent during the changing seasons than any other form. *S. retulus*, the commonest species, stands in the centre of the genus, while two extremes are expressed by the other members of the group.

The winter or sexually produced eggs are lodged in an ephippium or saddle-like modification of the shell, which is finely reticulate; while the shell is usually marked by fine anastamosing lines which, in some species, show clearly their derivation from a rather fine hexagonal marking.

The sexual periods, when males are produced, occur in autumn and spring. The males have few distinguishing characteristics, the form being that of the young female.

The opening of the vasa deferentia is back of the anus, hence these ducts cross the course of the intestine. They have ejaculatory muscles

about the lower part. The smaller species are frequently deeply colored with pink, purple and brown fatty deposits and the markings are more conspicuous than in the American *Eurycercus*, which is itself often brightly spotted with blue or purple. The aspect in the water is between that of *Eurycercus* and *Daphnia*.

The first mention made of any member of this genus in America is Say's description, repeated in Dekay's *Crustacea of New York*, of *Daphnia angulata*. This description which follows is quite sufficient to identify the genus, and indeed to indicate that either *S. americanus* or a related form is intended, but it is hardly competent to alter names the significance of which is quite clear.

"Sides striate with numerous parallel minute oblique lines; hind edge of the body with a prominent angle in the middle. Antennæ with four filaments on the upper and five on the lower branch. Color white or red. Length 0.1 mm. Stagnant water in the forests of the Southern states."

* **Simocephalus vetulus** Mueller.

PLATES XLIV, FIG. 7; LII, FIGS. 6-9.

Daphnia vetula—Baird, Herrick.

Daphnia sima—Mueller, Latreille, Bosc, Ramdohr, Gruithuisen, Desmarest, Lamarck, M. Edwards, Koch, Gmelin, Manuel, Jurine, Lilljeborg, Leydig.

This commonest and one of the largest species is apparently distributed over the northern hemisphere and abounds in all the more shallow lakes. The head is rounded in front and is not angled between the prominence of the eye and the beak. The body is very large and not abruptly angled above, the spine of the shell being inconspicuous and high, so that the free posterior edges of the shell lack little of equaling the greatest height of the shell. The shell is covered with minute dense striations which spring from the free edges. The pigment fleck is elongated in old specimens and the upper angle follows up beside the suture separating the antennary basin from the rest of the shell of the head. The antennules are ornamented with minute spines. At the lower angle of the shell are three curved spines which differ from the preceding filaments. The number of eggs which are produced at once is truly immense. Under favorable circumstances this species reaches a large size, falling little if any short of 3.0 mm. *S. vetulus* lives, by preference, among the leaves of aquatic vegetation. With us this species seems to live in the smaller pools as well as in lakes of some size. I am not able to see any difference in this respect between the various species.

*Simocephalus serrulatus Koch.

Daphnia serrulata—Koch, Lievin, Fischer, Lilljeborg.

Head narrow, extending anteriorly into a sharp spiny angle in front of the eye. Dorsal line of the shell abruptly angled or curved posteriorly, projecting to form a broad obtuse spine behind; this spine is serrate with sharp teeth and lies somewhat above the middle of the height of the animal, so that the free posterior margins of the shell fall much short of reaching the greatest height of the shell. Postabmomen of the usual form, with the claws armed with two series of spines or bristles, the outer being much the larger; anal teeth curved or angled, dentate; pigment fleck triangular or rhomboidal. Length 2.0 to 2.5 mm.

I am not sure that the three following species are more than varieties; the first in particular is very close to the European type.

[* Simocephalus americanus Birge.]

PLATE XLV, FIG. 9.

My own observations of this form made throughout the Mississippi Valley are not in complete accord with the description of Birge, but it seems improbable that there is any mistake in the identification. The very generally distributed form on which this species rests is subject to marked variations within certain limits. This species differs from *S. serrulatus* in the following points. The head, although prominent and spiny near the eye, is not angled between this prominence and the beak; in fact, it is either straight or simply curved. The pigment fleck is usually rhomboidal and only occasionally oval, triangular or irregular. In other respects the agreement is rather close; the terminal claws have two series of spines, one of which is larger (not, as said by Birge, equal); the outer series is not so much larger as in *S. rostratus*, but not nearly as inconspicuous as in *S. vetulus*. The terminal claws are rather evenly curved. This species is frequently colored with pink or brown markings. In old females the back is squarely angled above, forming a pocket for the eggs. The size falls short of that of the last species. I have found this species from the Gulf of Mexico to Minnesota. Professor Birge now recognizes this as *S. serrulatus*.

*Simocephalus rostratus Herrick.

Herrick '84.

This form is of the size and color of *S. americanus*, and approaches nearest to Schoedler's *S. exspinosus* in general characters. The back is arched above but not abruptly angled; the spine is as in *S. americanus* but not so low. The free posterior shell margins are somewhat shorter

than the greatest height of the shell. The head is produced below the eyes in an angle like a right angle, which is not spiny. The lower margin of the head is excavated to form a right angle, and in front of the smooth antennules forms a very prominent beak, beyond which the antennules reach but a short distance. The terminal claws of the post-abdomen are straightish and are more heavily spined than in the preceding; the anal spines are doubly curved or geniculate. The pigment fleck is rhomboid or pentagonal; the antennules are smooth. The abdominal processes differ somewhat from the previous species, in which the second one is rounded above, for in this it is squarely truncate. This species was found only in shallow pools at Ocean Springs, Miss., and was very carefully compared with *S. americanus*, which is also found there.

Simocephalus exspinosus Koch.

Head extending into an obtuse angle at the eye, pigment fleck rhomboidal. Shell without a spine; maximum height of the shell greater than that of the free posterior margin. Caudal claws with an unequal series of spines; anal spines evenly curved. There is little to distinguish the above from this species save the geniculate anal spines and the presence of a blunt spine on the shell.

Var. congener Schoedler has the lower outline of the head sinuate instead of angled.

Simocephalus daphnoides Herrick.

PLATE XLVI, FIGS. 5,6.

Herrick '83.

A curious transition form, found only south of the Tennessee river, was described in the American Naturalist for May, 1883, under this name. By an oversight a comparison made with *S. americanus* appeared as though made with *S. vetulus*. The general shape is oval; the greatest height of the valves lies near the middle and not posterior to it as in all the other species. The head is short, depressed, rounded in front; the beak is wanting; the lower margin of the head is straight. The pigment fleck is small, oval or irregular; the fornices are small and short. The antennules are smooth.

The post-abdomen is narrow, shaped more as in *Daphnia;* the terminal claws are straightish and fringed part way with spines; the anal spines are slightly curved. The processes of the abdomen are long, as in *Daphnia*. The shell is covered by the characteristic striations and extend into a blunt spine. In every detail, almost, there is an approach toward the genus *Daphnia*, while the general result is suffi-

ciently like *Simocephalus*. The lower angle of the shell is not armed with the peculiar curved spines as in all the other species. This species becomes over one-tenth inch long. In such old individuals the spine is nearly midway of the height.

One could wish a trifle closer link to *Scapholeberis* than that furnished by *S. angulata:* but, on the whole, the position of this genus can not well be called in question. America has four species out of the six known and but one of these certainly identical with the European, though others are probably closely related.

GENUS DAPHNIA.

Long considered the type of the family, this genus is most frequently seen, or, at least, is more conspicuous than any other group. It has already been pointed out that the forms here united are the extreme development of a diverging line. *Simocephalus* is the link connecting it with the typical forms of the family. As might be expected, this genus presents more puzzling problems than any of the others. It contains more peculiarities of structure and diversities of habit and development than any other of the genera. Here the sexual differences are most interesting. The young are hatched with a pendant appendage attached to the upper posterior angle of the shell, which soon becomes the rigid spine characteristic of the younger stages and males of the genus. The females almost immediately after birth commence the production of eggs by an asexual process. Groups of epithelial cells containing four each are formed and one of the cells of each group develops at the expense of the others, forming the egg. Many such eggs are laid simultaneously and deposited in the cavity between the shell and the dorsal part of the animal. The eggs are prevented from escaping by means of three long processes, of which the first is much the larger and curves forward. At stated periods in spring and autumn the males appear; the females of the generation in which occur the males have a tendency to produce eggs of a different sort charged with a different mission. At the same time the upper portion of the shell (that surrounding the brood cavity) becomes finely reticulated and pigment is deposited between its layers. This ephippium, as it is called, in allusion to its saddle-like form, is the case in which the winter egg is to pass the period of cold or drought which is to follow. The method of the formation of the ephippium is obscure and, in spite of the investigations of Lubbock and Smitt, considerable remains to be learned with reference to this interesting modification of the shell. Some rather careful study has been devoted to this subject by the writer, but it was unfortunately interrupted before completion. The

most promising method of pursuing the investigation is that of sectioning ephippial females in various stages with the microtome. A preparation of soap was employed with partial success as a medium for embedding.

Development of Daphnia.

Although the careful researches of Claus and Grobben have added much to our otherwise rather meager knowledge of the development of the *Cladocera*, there still remain many interesting points, particularly with reference to the individual species, which merit careful study.

The following observations relate to the single species *D. schæfferi* which was available during a short stay in Leipzig.

The winter eggs of *D. schæfferi* are two in number and are lodged in the well known manner in an ephippium.

The shape of these eggs is sharply ovoid, there being no distinguishable difference between the two ends. The position in the ephippium is not, as might be expected, with the longer diameter parallel to the axis of the body, but the posterior end is slightly elevated. This is undoubtedly due to frequent elevation of the abdomen between the valves during the extrusion of the eggs.

The color is dark green and the only protection as the egg leaves the ovary is a thick, tough shell which is at first so soft as to be susceptible to pressure. It is thus reticulated, apparently through the simple pressure of the walls of the ephippium.

The length is 0.43 mm.; width 0.33 mm. in the average, though eggs were occasionally found of an elongated form, measuring 0.48, 0.31 mm. The contents of the egg consist of spheres of greenish plasma of various sizes and fat or oil drops. These oil globules are not very numerous as compared with those of the summer eggs, and likewise never attain the dominant size seen in the latter. The various forms assumed by the plasma balls are perplexing but frequently result from the action of external agents. The cleavage stage was not seen, and if actual segmentation takes place, it must be inconspicuous as would be expected from the large quantity of yolk present. The differentiation of the blastoderm occurs very early, perhaps in the ovary itself, and the result is a tolerably uniform layer of prismatic cells. The egg now comes to a period of repose after the blastoderm has produced a second external envelope apparently by simple secretion.

This envelope consists of a fine structureless membrane. The egg, under ordinary circumstances, remains dormant during the winter in this most favorable stage. The reason for which is evidently the fact

that the differentiation has proceeded to the extent of producing the greatest number of protective layers without materially increasing the complexity, and thus the sensitiveness, of the organism. Under favorable circumstances the development proceeds farther and near one pole appears a slight indenture of the surface which grows deeper and seems to form a true invagination. This blastopore, if such it really be, remains for some time, generally till the two "Scheitel" plates appear. These "Scheitelplatte" are formed by a simultaneous thickening and lengthening of the cells of limited areas on opposite sides of the egg, near the opposite pole from that occupied by the blastopore. The "Scheitelplatte" are situated at right angles to a plane perpendicular to the blastopore. The nuclei of the cells of the "Scheitelplatte" are nearly 0.0208 mm. in diameter, while those of the other blastoderm cells are about half that size.

The egg remains a long time in this stage, while the following stages are passed through quite rapidly till the embryo assumes its nauplius form. The remainder of the development agrees, so far as seen, quite fully with that of the summer eggs, to which we will now return.

The summer eggs vary greatly in size and number, but are nearly as large as the winter eggs. The number is sometimes reduced to two or three or rises to as many as fifteen or even more. In color the eggs vary from green to brown. The fresh egg consists, as the winter egg, of two sorts of yolk spheres. The plasma or formative yolk contains colored globules of rather small size, distributed throughout the whole of the mass quite uniformly. The food yolk or oil globules assort themselves in two sizes; first, a few (generally three) very large oil drops, which persist throughout the earlier stages of the embryo; second, smaller globules of apparently the same character, which are quite numerous and form a very considerable part of the contents of the egg. In an egg of about 0.35 mm. in diameter, the largest of the smaller size of oil drops measured 0.029 mm., while the larger three exceeded 0.060 mm. The oil drops are distinguishable by their light refractive power, pellucidity and the intense dark brown or black color assumed when treated with osmic acid. The latter reagent affects the formative yolk but slightly. It will be seen that though the summer egg is nearly as large as the "Dauerei" in some cases, yet the relative amount of formative yolk is more diverse than at first appears.

The great similarity between the two sorts of eggs in *Daphnia schæfferi* is throughout striking as compared with *Moina*, the only one of the *Daphnidæ* the development of which is fully studied. In the summer eggs I have not been able to see the complete segmentation

described for *Moina*. The following stages are much as described by Grobben. An invagination occurs and a median swelling appears on the ventral aspect of the egg.

Labrum and second antennæ bud out and are soon followed by the antennæ, mandibles and two pairs of maxillæ, after which the five pairs of feet soon appear. In an early stage there is present a basal palpus to the second antennæ, a fact not before observed, and this persists as the small two-bristled wart found on the basal joint of the antenna. It is a conspicuous object in the embryo and is thus a true embryonic organ.

The eyes of the embryo appear as two separate pigmented flecks which approximate and are covered with an oval refractive body, which later is penetrated by the pigment and divides to form the small lenses. Soon after this the shell grows over the eye as described for *Moina*.

The first indication of the shell appears as two folds of the maxillary region of the back, being thickest laterally. These grow forward and backward to form the cephalic and body shield. At a little later stage there appears a very interesting modification of the shell which stands in close relation to the growth of the brood sac. A slight protuberance appears on the margin of the shell in the median dorsal line and extends toward the abdomen. It grows much more rapidly than the other parts of the shell and, in a later stage, forms a comparatively enormous tail, which curves under the animal between the shell valves which now extend beyond the body. This "tail" extends well along the ventral margin of the shell and reminds, by its position, of the tail of a frightened dog. The true tail, or post-abdomen, is, in the meanwhile, well developed and is constantly kicking the useless protuberance of the shell upwards. As the animal leaves the egg this projection becomes straightened as in the young *D. pulex*, finally becoming the still considerable spine, though it is proportionately much shorter than in the embryo. The spine becomes shorter with successive moults, and the mature form has only a slight rounded knob in place of a spine more than half the length of the body.

The use of the long spine in the young *Daphnia* is a matter of interest. Its length agrees pretty well with that of the brood cavity and it seems possible that it serves to prevent the shell from bending abruptly down when it is only partially removed during the moult and thus breaking off and so leaving a portion of the clothing of the brood cavity therein to become a source of irritation. This is more necessary for the young, since the brood cavity is narrow and the shell weak, so that while the outer shell is removed like a glove from the finger, it cannot be pulled upward or downward, but directly

backwards. It is well known that male *Daphniæ* often have the spine while the females may have none, and here again it is possible that the narrower cavity over the abdomen requires this assistance, while this is not the case with the females.

The shell gland is early formed and the branchial lamellæ of the feet appear almost simultaneously with the feet themselves as distinct lobes. The branchial chamber is not a simple chamber, but is essentially a curved tube, as can be very well seen in the last foot of the adult. This tube doubles upon itself and crosses in the manner of a loop and a constant stream flows rapidly through it.

The nervous system is, at first, paired from beginning to end and first unites anteriorly, the ocular ganglia fuse after the union of the two pigment flecks in the compound eye, then the cephalic ganglion is formed by the union of the two præœsophageal ganglia, and the commissures passing about the œsophagus. I have not been able to determine if the subœsophageal ganglia become fused. From the anterior ganglia spring the nerves to the antennæ and jaws, which latter are larger in the embryo.

It is greatly to be regretted that no sufficient revision of *Daphnia* can now be attempted. This is partly due to the very imperfect nature of the descriptions and partly to the scattered literature of the group. We here supply nothing more than a provisional key and synoptical descriptions. I take pleasure in acknowledging the substantial assistance, in respect to recent literature of the group, received from my friend, Professor Birge, as also for valuable suggestions respecting *Cladocera* in general.

KEY TO THE GENUS DAPHNIA.

I. Pigment spot present.
  A. Anal margin of the post-abdomen deeply excavated. . . **schaefferi,** 187
  B. Anal margin slightly if at all sinuous.
    a. Head very short and regularly curved from the heart to the beak. . . . . **psittacea,** 187; **atkinsonii,** 188
    b. Head not very short or regularly curved.
      * Claws of post-abdomen with a distinct comb of spines.
        † A strong toothed process from the dorsal margin of the head at some time of life.
          ‡ Spine long, straight. . . . . **clathrata,** 188
          ‡‡ Spine short, curved. . . . . **minnehaha,** 189
        †† No strongly toothed dorsal process at any period in either sex.
          ‡ Head with a helmet-like crest.
            ⁂ Spine long, springing from the dorsal angle, curved dorsad. . . . . **exilis,** 190

§§ Spine moderate, springing from the middle of the caudal margin. . . . . **arcuata,** 190
‡‡ Head uncrested.
§ Spine short or absent.
‖ Abdominal process united at the base. . **gibbosa,** 191
‖‖ Abdominal processes discrete.
¶ Spine near the middle of the caudal margin.
° Anal teeth 20 to 22. . . . . **ovata,** 191
°° Anal teeth 9 to 10. . . . . **obtusa,** 191
¶¶ Spine at the dorsal angle. . . . . **alpina,** 192
§§ Spine of considerable length.
‖ Spine near the middle of the caudal margin.
¶ Ventral margin of the head convex. . **hastata,** 192
¶¶ Ventral margin of head concave.
° Eye distant from the margin of the head. . . . . **ornata,** 192
°° Eye near the margin of the head.
x Abdominal processes united at the base. . . . . **schoedleri,** 193
xx Abdominal processes discrete. **brevispina,** 193
‖‖ Spine nearer the dorsal angle. . . . . **pulex,** 193
** Claws of the post-abdomen without a basal comb of teeth.
† Antennal setæ thick, first segment longer than the second.
‡ Spine near the middle of the caudal margin. **ventricosa,** 195
‡‡ Spine above the middle of the caudal margin. . **caudata,** 195
†† Antennal setæ with the second segment longer than the first.
‡ Head helmeted. . . . . **hyalina,** 195
‡‡ Head not helmeted.
§ Abdominal processes united.
‖ Dorsal margin strongly carinate. . . . . **sarsii,** 198
‖‖ Dorsal margin slightly or not carinate.
¶ First abdominal process much the longer.
° A deep depression separating head and body. . . . . **paludicola,** 198
°° A very slight depression separating head and body. **longispina,**199; **minnesotensis,**199
¶¶ Abdominal processes nearly equal.
° Anal claws 12 to 22. . . . . **cavifrons,** 200
°° Anal claws 7 to 23. . . . **microcephala,** 200
§§ Abdominal processes discrete.
‖ Abdominal processes short, equal. . . . **rosea,** 200
‖‖ First abdominal process twice as long as the second.
¶ Beak not greatly produced ventrad. . **aquilina,** 200
¶¶ Beak greatly produced ventrad. . . **lacustris,** 201
‡‡‡ Head with a dorsal toothed crest.
§ Crest just in front of the heart. . . . . **dentata,** 201
§§ Crest over the bases of the antennæ. . . **dentifera,** 202

II. Pigment spot absent.
A. Head not helmeted or but slightly so. . . . . **longiremis,** 202
B. Head helmeted.

a. Eye near the end of the head. . . . . **magniceps,** 202
b. Eye not near the end of the head.
* Abdominal processes free. . . . . **kalbergensis,** 203
** Abdominal processes united. . . . . **cucullata,** 203

[Not in the key: **dubia,** 196; **pennata** and **curvirostris,** 194; **thorata,** 197; **hermani,** 198; **similis,** 204; **bolivarl,** 205; **carinata,** 205; **lumholtzii,** 206.]

Daphnia schæfferi Baird.

PLATE LI, FIGS. 1-5.

Daphnia pennata — Mueller.
Daphnia pulex—Straus, Koch (fide P. E. Mueller).
Daphnia magna—Lilljeborg, Leydig, etc.

The largest species of the genus, is of an elongated oval and ventricose form. The head is short and evenly rounded. The spine is entirely absent in old females and of only moderate length in the young. The antennules of the male are long and have a very long flagellum. The post-abdomen is narrowed suddenly below the anus so that the spines consist of two sets; the terminal claws are spiny at the base. The species may be recognized at once by the concavity of the dorsal margin of the post-abdomen. The plate will make any detailed description superfluous. A common species in Europe, but not yet found in America.

The sole distinction between this species and *D. magna* Straus is found in the fact that the intestinal cæca are very long and recurved in *D. schæfferi* and short and thickened at the free extremity in *D. magna*. We fail to discover sufficient reason for separating them.

Daphnia psittacea Baird.

Baird '50; Schoedler '58; Fric '72[1]; Kurz '74; Hellich '77; Herrick '84; Elymann '87; Daday '88.

Head short, rounded in front, beak very short. A depression separates the head from the oval, ventricose body. Spine long directed dorsad. Eye distant from the margin of the head. Post-abdomen long, narrowed toward the end, somewhat sinuous in the caudal margin. Anal teeth about ten. Claw bipectinate, rather long. Length 1.8 to 1.9 mm.

This species is at once recognized by the head, which is very short and evenly curved, or nearly so, from the heart to the beak. The shell is high, oval, with a rather short spine. The fornices are wide and angled behind. The antennules are longer than in most species; the post-abdomen is very large, but narrows toward the end and has comparatively few anal teeth, which are of unequal size. This is one of the largest of the genus. Not yet found in America.

Daphnia atkinsonii Baird appears to us but a variety of this species. There is said to be no depression between head and body and the anal teeth diminish dorsad instead of being nearly equal as in *D. psittacea*. Considerable disagreement exists in the various descriptions. Daday's figures show no grounds for separating the species.

* Daphnia clathrata Forbes.

Forbes '93.

"A species of moderate size, with short, deep head, medium to very long posterior spine, minute pigment fleck, and pectinate tarsal claw. In the immature female there is a prominent angle just above the swimming antennæ, like that of *D. dentifera*. In the adult female the head, measured vertically across the rostrum, is twice as deep as its length from the base of the antennæ to the middle of the front. It is sharply keeled rather than crested, very broadly rounded, its lower margin very slightly convex or quite straight, and its rostrum well marked in the adult. The eye is close to the front, the transparent orbit reaching to the margin of the head, of medium dimensions, its antero-posterior diameter contained twice in the space between the posterior margin of the head. The pigment speck is very minute, placed behind the lower half of the eye and nearer the posterior margin of the head. The fornices are not prominent. Beginning midway between the antenna and the eye, they arch broadly above the base of the former, making an obtuse angle a little beyond the antenna, and continuing as a slight carina backwards and downwards for a little distance on the side of the valve.

"The ventral margin of the shell is more broadly arched than the dorsal, the latter being in the immature female nearly straight from the heart backwards. The valves are conspicuously quadrangularly reticulate, spinose on their lower edges nearly to the beak, and on the upper edge to the vicinity of the heart. The posterior spine is very long, straight, slender, spinose to the tip, contained in average cases not more than twice in the length of head and body without the spine.

"The antennæ are rather short, about half as long as the distance from the posterior margin of the eye to the base of the posterior spine. The swimming hairs are two-jointed, the basal joint the shorter. The dorsal abdominal processes arise in immediate connection, but are not united at their base. The anal furrow has about a dozen teeth on each side, and the caudal claw has a comb of three or four conspicuous teeth at its base besides a little group of smaller ones. Length of ovigerous female 1.7 mm. to the base of the spine; the greatest depth 0.85 mm. The male not seen. Occasional in Grebe lake, Yellowstone Park."

*Daphnia minnehaha Herrick.

PLATES XLIX, FIGS. 1, 2a; L, FIGS. 1, 2; LII, FIGS. 1-3.

Herrick '84; Birge '91.

This species, which occurs in small pools in autumn (affluents of Minnehaha creek, etc.,) closely corresponds apparently to Sars' *Daphnia carinata* but differs in numerous points. It, in fact, is more nearly related to *D. pulex* than the group under which that species is placed.

The form is oval, arched above, narrowed posteriorly, terminating in a rather short spine which curves lightly upwards. In males and young females the spine springs from the upper angle, but in old females having many summer eggs the spine is nearly median. The head is depressed, strongly arched and keeled slightly above the eye, which occupies the extreme end of the forehead. The keel of the head extends into a slight angle over the heart and continues down the back. In young females and in males the slight angle is replaced by a strong knife-like projection which extends into from one to four sharp teeth, the anterior tooth being directed forward. The males, in particular, have this feature emphasized. *D. longispina* has a somewhat similar projection, but the more nearly related forms seem not to show this peculiarity. The beak is slightly curved and the lower margin of the head is slightly sinuate. The shell has the usual square reticulations and is usually very transparent but in peaty waters becomes brownish. The size is small but variable; 1.8 mm. is a common measurement. The post-abdomen is narrow, the claws are armed with four or more teeth and a series of lateral bristles. The anal spines are eleven or more in full grown females and decrease only moderately upward. The processes of the abdomen are distinct. The males are smaller and strongly carinated above and of the same form as young females. The antennules are rather long, with a short lateral and a long terminal flagellum, which latter is more than twice the length of sensory setæ which are partially lateral. The first foot has a strong claw and a long flagellum, while the second feet have a small spiny hook. There is a single abdominal process which is not hairy as in *D. pulex*.

The following measurements may be added: Female—Length 1.44 mm., spine 0.33 mm., head 0.26 mm., depth of head 0.46 mm. Male—Length 1.0 mm., spine 0.17 mm., head 0.20 mm., depth of head 0.31 mm., length of flagellum of first foot 0.35 mm. Ephippial female —Length 1.64 mm., spine 0.20 mm., head 0.35 mm., depth of head 0.8 mm., greatest depth of shell 0.94 mm.

The ephippial females appear in July in the vicinity of Minneapolis, and at that time it is rare to find a female with the toothed crest developed. *D. dentifera* Forbes is closely related but has smooth claws.

* Daphina exilis sp. n.?

PLATE LII, FIGS. 4, 5.

It is admittedly undesirable to describe a specimen instead of a species, but the form for which the above name is provisionally proposed is so peculiar and its locality so little studied that a description is given based on a single young female. It will be understood that the ovigerous female would differ in the length and position of the spine, size of crest and form of the abdominal processes.

A daphnid of moderate size with crested head, long spine and dentate caudal claw. Nearly colorless. Head projecting in the line of the axis of the body, crested from the eye to a point cephalad of the heart, but truncate in front. Ventral outline nearly straight, beak not projecting, antennules very short and applied almost at the end of the beak, which does not lie between the valves. Eye of rather large size, with few crystallines, near the ventral margin. Pigment fleck small, nearer to the caudal margin of the head than to the eye. Cœca narrow, strongly curved. Antennæ short and stout, second segment of the setæ longer than the basal. Fornix moderate. Valves sub-oval, strongly curved ventrally, dorsal outline straight from in front of the heart to the spine, which is very long and curved dorsad. In this specimen the spine is longer than the entire valve. There is no dorsal emargination between the head and body Dorsal margin armed with spines beyond the heart, ventral margin spined more than half of the length. Valves marked with the usual quadrangular meshes. Post-abdomen narrowed toward the end. Anal margin sinuate. Anal teeth about eight, nearly equal. Claw short and moderately curved, armed with a continuous series of spinules and a comb of fine spines near the base. Length, exclusive of spine, 1.15 mm.; length of head 0.38 mm., height of head 0.54 mm., height of shell 0.65 mm., length of spine 0.84 mm., diameter of eye 0.10 mm, length of base of antennæ 0.26 mm., claw 0.09 mm. The abdominal processes in this specimen are not in their mature form. It is not certain that the dense hairiness of the anal margin above the teeth is an adult character. It would appear that the crest is normally a strongly projecting cephalic helmet, but this is but conjectural. Found in weedy pools fed by irrigation canals at Albuquerque.

* Daphnia arcuata Forbes.

Forbes '93.

"Head helmeted, rounded in front, length one-third that of the shell, front concave, beak produced, extending beyond the sensory hairs of the antennæ. Eye small, about midway between the mandi-

bles and the front of the head, and about midway between the tip of the beak and the dorsal surface of the head. Pigment speck very small, less than half the diameter of a lense of the eye, and placed midway between the eye and the posterior margin of the head. The latter concave, the beak extended backward and applied against the margin of the shell. Swimming antennæ reaching the middle of the shell, their hairs moderately robust, the first segment not longer than the second. No emargination separating head from body, but the dorsal surface very slightly sinuate there. Abdominal processes all distinct, anterior much the longest. Caudal claw with accessory teeth, about six in number, the three proximal the largest. Anal spines about ten. Posterior spine of the shell given off from the middle of the valves, in the adult female a third to a half as long as the valve. Shell moderately coarsely marked in quadrangular areas, the lower and dorsal margins spinulose from the middle backwards. Length 2.0 mm., depth 1.0 mm. Heart Lake, Yellowstone Park."

Daphnia gibbosa Hellich.

Hellich '74 and '77; Elymann '87.

Body large, very high. Head depressed, ventral margin strongly concave. Eye large, with few crystallines. Antennæ long, scaly. An obvious depression separates head and body. Spine short, above the middle. Abdominal processes united. Anal teeth 17 to 19, diminishing dorsad. Claws with a comb of teeth. Color reddish. Length 2.01 mm.

Daphnia ovata Sars.

"Caput a latere visum ante oculum fere angulatum, margine inferiore leviter con cavo in rostrum longum apicem versus attenuatum, extremitate tenuissima exeunte-spura visum ut in D. pennata cordiforme. Testa cetera a latere visa ovata, margine superiore et inferiore in femina adulta fere æquæs arcuatis, postice in medio spinam formans brevissimam vel omnino obsoletam. Processus anteriores duo abdominis disjuncti. Margo posterior postabdominis in medio sinuatus, utrinque aculeis 20-22 armatus. Color albido—flavescens vel virescens. Longit. circit 3 mm."

No one besides Sars seems to have seen this species. We suspect it is simply *D. schæfferi*.

Daphnia obtusa Kurz.

Lilljeborg '53 (pulex); Kurz '74; Hellich '77; Elymann '87; Daday '88.

Head short, front rounded, ventral margin slightly sinuate, beak short, acute turned caudad. Eye remote from the margin of head. Crest absent. Body oval, margins convex, spine nearly absent. Post-

abdomen not ciliate, of moderate size. Anal teeth 10, nearly equal. Claws bipectinate. Abdominal processes discrete. Length 1.08 mm.

It still seems probable that this is an age form of some species with longer spine.

Daphnia alpina Daday.

Daday '88.

Head short, somewhat produced ventrad, front rounded, ventral margin almost straight; beak rather acute, short, extending ventrad. Eye large, rather remote from the margin of the head. No crest. Shell almost round, ventral margin obviously rounded; spine absent or very short, simply forming an acute angle. Post-abdomen small, laterally setose, bearing 11 to 12 anal spines which are short and curved and slightly diminish in size dorsad. Claw with a comb of long teeth and a continuous series of fine spinules. Abdominal processes discrete. Length 1.2 to 1.9 mm., depth 0.9 to 1.15 mm.

The resemblance to *D. obtusa* Kurz is very close, but that species has the sides of the post-abdomen smooth, the ventral margin of the head concave and the spine near the middle of the caudal margin of the shell. The shell is longer and more oval in outline. We should wish to be very sure that these are not both old individuals of a species having the usual spine in younger stages.

Daphnia hastata Sars.

A large species of reddish color, with strongly depressed head, whose ventral margin is convex. Shell oval, with a long spine. The abdominal processes are long and approximate. Anal spines 16. Length 3.0 mm. This species was inadequately described by Sars and probably should be dropped.

Daphnia ornata Daday.

Daday '84[1] (serrulata); '88.

Head not separated by a depression from the thorax. Beak rather acute, short, turned ventrad. Eye distant from the margin of the head. Shell oval, margins rounded, with a moderate spine directed caudad. Post-abdomen scarcely attenuated apically with eight to ten curved anal spines, diminishing dorsad; sides setose. Claw with a basal series of spines and a continuous series of fine setæ. Abdominal processes discrete, ciliate. Length 1.0 to 1.5 mm., height 0.85 to 1.0 mm. The ventral margin of the head in this species is more curved than in *D. alpina*, and this might well be a younger form of *D. obtusa*, though the setæ on the sides of the abdomen are not noted in that species.

Daphnia schoedleri Sars.

Schoedler '58 (longispina); Sars '61; Hellich '77; Elymann '87; Daday '88.

Head arched in front, ventral margin gently sinuous, beak acute, projecting ventrad. Eye large, near the margin of the head. Body oval, spine long. Post-abdomen of moderate size, with 12 [14 to 16] anal teeth. Claw with comb of spines. Abdominal processes discrete but approximate [Daday] or distant from each other [Elymann].

There is wide disagreement between the various descriptions of this species.

Daphnia brevispina Daday.

Daday '88.

Head short, slightly projecting ventrad, front strongly rounded, ventral margin somewhat sinuate. Beak short, acute, inclined ventrad. Eye distant from the frontal margin of the head. Shell oval, with a slight depression between head and thorax, margins arcuate, with a very short spine. No crest. Post-abdomen rather long with delicate lateral setæ; anal teeth 12, curved, almost equal. Claw with a comb of spines and a continuous series of fine setæ. Abdominal processes discrete, setose. Length 1.2 to 1.8 mm., height 0.75 to 1.2 mm.

* **Daphnia pulex** De Geer.

De Geer 1778; Hellich '77; Lutz '78 and '79; Elymann '86; Daday '88, Matile '90.

Body large, stout and thick, rather opaque, reddish. Head broad, depressed, front protuberant. Ventral margin of head deeply concave. Beak acute, curved backward. Fornix high. Eye small, with few lenses. Antennules short, conical, extending but little beyond the beak. Antennæ short, slender, evidently marked with scuta, with long densely pectinate setæ. The shell is not separated from the head by a depression in mature females and is oval in outline. The ventral margin is much more strongly arched than the dorsal. Spine very short, straight, inclined upward and inserted above the middle of the posterior margin. Shell margins with short spines. Surface reticulate in fine quadrangles. Cæca short, clavate, curved dorsad. The abdominal processes approximate; the first twice as long as the second; the third small. Post-abdomen long, narrowed toward the end. Its distal end is rounded. Anal teeth 12 to 14, nearly equal. Claws curved, with two combs of teeth, the higher consisting of six to seven teeth, the lower of three to four. Length of female 2.15 mm., height 1.23 mm., spine 0.16 mm. It is at present impossible for the writer to unravel the relations of the numerous varieties and supposed species of the *pulex* group. Probably most of them are simple synonyms. The following American varieties may be mentioned:

* **Daphnia pulex** var. **denticulata** Birge.

The lower margin of the head is said to be less convex [concave?] than *D. pulex*. The abdominal processes are less hairy, there is a continuous series of spinules on the claw and a larger number of anal spines—18 to 20. Daday figures claws such as Birge describes.

* **Daphnia pulex** var. **nasutus** Herrick.

PLATE XXXV, FIGS. 1-4.

This in some respects is more like the type. It has an elongate oval form with spine of variable length arising from above the middle. The impression between head and body is slight. The ventral margin of the head is concave and the beak is curved caudad. The terminal claw of the post-abdomen is furnished with two combs of fine teeth. The anal spines are 10 to 14. The abdominal processes are hairy. Neither this variety nor the above seems to possess the two teeth on the front margin of the claw.

* **Daphnia pulex** var. **pulicaria** Forbes.

This seems to closely resemble the type. The fact that the antennæ are ornamented with spines rather than scales is noticed. The first abdominal process is smooth, as it is also stated to be in the European form by some authors. The male is said to differ more, but comparison of Forbes' figure with that of Elymann reveals nothing of importance. (Elymann figures spines rather than scales on the base of the antennæ of the female.)

[**Daphnia pennata** Sars.]

"Antecedenti (*D. pulex*) simillima, caput autem a latere visum latius, rostro breviore, supra visum testa cetera parum angustius fere cordiforme, antice acuminatum. Processus anteriores duo disjuncti. Margo posterior postabdominis in medio sinulo parvo et infra hunc utrinque aculeis 16-18 armatus. Color ut in antecedente. Longit 0.2½ mm."

Although admittedly very close to *D. pulex*, it is said to differ in the broad depressed head, which is uniformly rounded in front and deeply excavated in front of the beak, which is short and deflected. The post-abdomen has 16 to 18 teeth. The antennules of the male are almost as long as the head, bearing a long pointed flagellum and a short lateral seta.

[**Daphnia curvirostris** Elymann.]

The differences relied on to distinguish this species from *D. pulex* seem to us quite inadequate. The head is more depressed and this gives to it a quite different appearance. The male antennule is thickened slightly at the middle and the flagellum is longer. The hairy abdominal process is absent.

Daphnia ventricosa Hellich.

Hellich '77; Elymann '87.

A large pelagic species without the toothed comb of the claw. The head is depressed, small, with rather protuberant front and long beak inclined caudo-ventrad. The short oval shell is deeper than the head, well rounded above and below. Spine long and straight, springing from the middle of the caudal margin. The antennal setæ are short and thick and have the first segment longer than the second. The first abdominal process is twice as long as the second, with which it is united. The post-abdomen narrows toward the end and is hairy laterally. Anal spines 14. Claws with setæ. Length 2.28 mm.

Daphnia caudata Sars.

Fischer '54 (longispina).

A large species without basal spines upon the claws. Head somewhat depressed, about one-third as long as the body, ventral margin slightly concave; beak long, inclined caudo-ventrad. Shell oval, with no depression between body and head. Spine long, springing from the middle of the caudal margin. Eye near margin of head, with few crystallines. Antennæ with short thick setæ whose basal segment is longer than the second. Post-abdomen narrowed toward the end. Anal spines 9 to 12. Claw with a row of setæ on the concave, and two spines on the convex aspect. The two cephalic abdominal processes united. Length 2.3 to 2.67 mm.

This species is said to resemble *D. longispina*. It would appear to be closely related to *D. ventricosa*.

* **Daphina hyalina** Leydig.

PLATES XXII, FIGS. 7, 8; XXVII, FIG. 6; XXXV, FIG. 16; XLIX, FIGS. 3-5; LIII, FIGS. 1-4.

Leydig '60; Sars '64 (galeata); Hellich '74 (gracilis); P. E. Mueller '68 (pellucida); Birge '78 (lævis); Herrick '83

The general form and appearance down to the minute details in this species are similar to *D. kahlbergensis*, with which it is almost always associated, except the head which is subject to an astonishing range of variation. A comparison of Figs 1 and 5 of Plate LIII, which were drawn by camera upon the same slide, illustrates the similarity. The body is pellucid. Shell, sub-oval, with long, straight, toothed spine as long as the body without the head, and inserted high up. Post-abdomen narrow with discrete processes, anal teeth about ten, terminal claw finely fringed or smooth. Eye small, either near

the margin and occasioning a prominence in the ventral outline or retreating from it. Macula nigra small or almost non pigmented. Gastric cœcca slender. Antennæ weak. The typical form of head is that of Fig. 3. Plate LIII, but the outline may be evenly rounded. The range of variation is well shown by the various figures. The young have no horn on the head. The spine of the shell is nearly as long as the whole animal in the young. The male of our form is 1.2 mm. long, excluding the spine which measures 0.47 mm. The flagellum is a very little longer than the sensory setæ, and there is a very minute lateral flagellum. A peculiarity of this species is the scattered thorny armature of the spine of the shell. There is but little change in the form of head with age. The form of the last feet is peculiar. The ephippium occupies comparatively a small part of the valves and the spine becomes very short and quite smooth. The sexual period occurs in September and October.

(*Daphnia dubia Herrick.)

PLATE XLIX, FIGS. 7, 8.

Our *D. dubia* may prove distinct. It is nearly related to *D. hyalina*, but the head is strongly crested all around and the eye is withdrawn, in young as well as old specimens, toward the middle of the head. This peculiarity is shared in this degree by no other *Daphnia*. The form is as in *D. pellucida*, but the spine is more slender and directed upward. The head is shaped much as in *D. vitrea* in the young, but is much less prominent. The older form has a shorter and more slender spine (none were seen in the ultimate or spineless stage). The head is more evenly rounded, but still well crested. The abdomen is very slender and the anal teeth diminish rapidly in size from below upward. The claws are very short and armed down the whole length with fine bristles. The abdominal processes are well united at the base in old specimens, so that the second seems a small process of the first. The shell is very transparent and the spine is very long. In a young specimen the spine was 1.0 mm., the body 0.7 mm., and the head 0.4 mm. In this specimen the spine was slightly curved, the head elongate with a slight ridge in front. Another individual had the spine 1.1 mm. long, while the remainder of the animal was 1.3 mm. This specimen also had a knife-like hyaline ridge on the crest, which was obliquely truncate in front; it also had numerous summer embryos in the brood sac. The spine was perfectly straight and but slightly inclined upward. Older individuals have a rounded crest as figured and no ridge. The spine is relatively somewhat shorter but much more slender. The characters which most clearly distinguish

this species are the well crested head, which in young as well as sometimes older specimens has a median hyaline ridge, the withdrawal of the eye from the margin and the very long spine. It resembles *D. galeata* in earlier stages. It is very much like *D. lævis* or, in other words, is in the group of *D. hyalina*. This form has only been found in autumn, September to November, Lake St. Croix and Richfield in Hennepin county.

[*Daphnia thorata Forbes.]

Forbes '93.

"This species belongs to the *hyalina* group, and may possibly be entitled only to varietal rank. The distinctness and constancy of its characters, however, in collections made by us in Flathead and Swan lakes in western Montana, and the number of minor points in which it differs from *hyalina*, as most recently described, lead me to distinguish it as a specific form.

"It is oval in outline; the long and slender posterior spine is placed at or a trifle above the middle; the length of the head is about a third that of the valves of the shell excluding the spine, and there is no trace of dorsal emargination between head and body. The head is narrowed toward the base and elongated forward in a way to give it the outline of a bell jar with a flaring base. Its front is broadly and regularly rounded, its ventral margin usually conspicuously concave and closely like the dorsal, although occasionally the head is straight or convex beneath. The posterior margin is either straight or slightly concave, and the beak stands free from the front margin of the valves, and by its extension downward not only covers the antennæ but reaches clearly beyond the tips of the sensory hairs. The eye is of medium size, placed far back of the front of the head and equidistant from the tip of the beak and the dorsal junction of the head and body. The pigment speck is of moderate size, placed directly behind the eye, and much farther from it than from the posterior margin of the head. The antennæ are moderately stout, entirely smooth except for inconspicuous transverse rows of minute appressed hairs upon both peduncle and rami, and a row of short, tooth-like spinules at the distal end of each segment. The swimming hairs are rather slender, the second joint commonly decidedly shorter than the first. Fornices slight, arising above and a little behind the eye and terminating directly behind the antennæ, above the bases of which they project but slightly. The lower margin of each valve is set with the usual spinules almost to the beak, and the dorsal margin is similarly armed for a distance in front of the spine about equal to half the length of

the latter. The valves are marked off by fine lines into large quadrate meshes. The dorsal abdominal processes rise separately, the two anterior, however, in immediate contact at their bases. The first of these is decidedly the longer, but the third process is distinct, although low. The anal setæ are two-jointed, the second joint the shorter. The abdomen is regularly narrowed backwards, and the anal groove is provided with twelve to fifteen teeth on each side, commonly the latter number. The terminal claws are without accessory comb. The intestinal cœca are short, not longer than the diameter of the eye, and extend directly forward. Length 2.0 to 2.5 mm.; depth half the length, sometimes a little more. Length of spine variable, but commonly about equal to the depth of the shell."

As to the specific rank of this form we suspend judgment for the present.

[**Daphnia hermani** Daday.]

Daday '88.

Head broad, compressed, front rounded, beak round, projecting ventrad. Eye large. Macula nigra absent. Shell oval, with a long spine. Abdominal processes discrete. Claws without teeth but ornamented with a continuous series of fine setæ. Anal teeth six, diminishing dorsad. Length 0.5 to 0.8 mm.

This we may unhesitatingly regard as a form of *D. hyalina*.

Daphnia sarsii Schoedler.

Sars '60 (carinata); Schoedler '77; Elymann '87 (carinata).

A large yellowish species with a strong dorsal keel. Head uniformly curved, slightly concave behind the eye, with a long oblique beak. Dorsal and ventral margins curved. Spine short and curved, springing from near the middle of the caudal margin. The abdominal processes long and united at the base. Claws without teeth. Length 2.5 mm. The very insufficient description may help to place a form not recognized since Sars described it.

When *D. carinata* King is finally placed among its congeners this species will preoccupy Sars' name.

Daphnia paludicola Hellich.

A large species of a dirty yellow color. Head depressed, front scarcely protuberant, ventral surface slightly concave, beak sharp, short. Antennules very small. Shell deep, oval, with a short curved spine springing from the middle of the caudal margin. First abdominal process much longer than the second, to which it is fused. Post-

abdomen small. Anal teeth 12 to 14. Claws with a series of fine setæ. Length 2.18 mm. In the male the lower margin of the head is excavated and the flagellum of the antennules short and straight.

Daphnia longispina Mueller.

Mueller 1785; Straus-Durckheim '19-'20; Baird '50 (pulex var. longispina); Leydig '60; Sars '61, and '64 (affinis); Mueller '68; Plateau '70; Lund '70-'71; Kurz '74; Hudendorff '76; Hellich '77; Lutz '78 and '79; Herrick '84; Elymann '87; Walter '88; Daday '88; Matile '90.

A slender species of moderate size and transparent. Head not so deep as the body, from which it is not separated by a depression, slightly concave behind the eye. Beak long and directed caudo-ventrad. Eye large, near the margin. Shell oval; spine long, situated above the middle line and curved upward.

Two largest abdominal processes both directed cephalad and somewhat united. Anal spines 10 to 12. Claws with a series of fine setæ and two spines on the convex aspect. Length 2.0 to 2.5 mm.

Flagellum of the male antennule hardly longer than the sensory setæ. The young have three teeth above as in *D. minnehaha*. There is a great deal of diversity of opinion as to the value of this name. Not that there is any doubt of the existence of a widely distributed form which in general is that intended by Leydig and others, but the variation is so great that the possibility remains that more than one species is included under the one title.

P. E. Mueller recognizes two varieties depending chiefly upon the length of the spine.

***Daphnia minnesotensis** sp. n.

PLATE L, FIGS. 10-12.

Herrick '84 (rosea.)

The later descriptions of *D. rosea* leave no doubt that this is a distinct species. The abdominal processes are somewhat united at the base instead of "manifeste discretis," and the first is much longer. In many respects the species is near *D. longispina*. The original description is given: "In form very like *D. longispina*, this species, which is the only representative of this smooth-clawed, unkeeled group yet found in America, might perhaps be appropriately united with that species.

"Body oval, moderately ventricose; head of moderate size, lower margin nearly straight; eye situated in the anterior prominence. The beak is not very prominent. The upper outline of the head is slightly concave above the eye or rather less convex. The head is separated

from the body by a marked depression. The spine of the shell springs from the upper angle or is quite wanting. The post-abdomen is of moderate size, somewhat narrowed toward the end. The claws are smooth, the anal spines nearly equal, straight, about fourteen in number. The abdominal processes are not coalesced or but slightly so. Length 1.50 mm. to 2.0 mm. The species was collected sparingly in a large gathering of *D. pulex* from a small lake in early spring.

"The size and conformation of the abdominal processes are very variable and the long and very slender spine is frequently absent."

The antennules are very short. Males unknown.

Daphnia microcephala Sars.

A small transparent form, head only half as deep as the shell, slightly concave ventrally and ending in a short blunt beak. Shell elongate oval with a slender somewhat curved spine from the middle of the caudal margin. Abdominal processes nearly equal and united at the base. Anal spines seven. Claws without teeth. Length 0.75 mm.

This is also a species requiring farther study.

Daphnia cavifrons Sars.

A reddish species with the head separated from the body by a depression, depressed, ventral border excavated, beak large. Shell ventricose with a short spine from near the upper angle. Abdominal processes nearly equal and united at the base. Anal teeth 12. Claw without teeth. Length 1.5 mm.

I am not sure of this and the preceding.

* **Daphnia rosea** Sars.

Of moderate size, reddish in color, and resembling *D. longispina*. Head depressed and not separated by a depression from the thorax, somewhat excavated in the ventral margin, beak blunt. Shell oval, spine long, springing from above the middle and directed obliquely dorsad. The two abdominal processes thick, equal, discrete. Anal spines 12 to 14. Claw without teeth. Length 1.9 mm.

The American form identified with this species is more like *D. longispina*.

Daphnia aquilina Sars.

A species of medium size, transparent. Head depressed, protuberant at the eye, excavated behind it, the beak lying in the same plane as the frontal projection and strongly curved caudad. Eye large. Shell oval, slightly separate from the head. Spine above the middle

line very slender and short, directed dorsad. Abdominal processes long, approximate, the first twice as long as the second. Anal spines 16 to 17. Length 1.83 mm.

Dapnia lacustris Sars.

Very similar to *D. aquilina* and to *D. rosea*. The head is depressed and excavated behind the eye, the beak projecting ventrad below the level of the front. The eye retreats from the front and is large. The shell is oval and the spine is straight, springing from the middle of the caudal margin. The abdominal processes are discrete but approximate. Post-abdomen as in *D. longispina*, with 14 to 16 teeth. Length 2.21 mm. This is doubtless to be reckoned among the varities of *D. longispina*.

Daphnia dentata Matile.

Matile '90.

I translate the description, l. c. p. 14.

Body transparent. Head low and rounded cephalad; its ventral margin rather short and concave. Apex of beak directed ventrad [nach unten]. Antennal setæ three-jointed, the last segment very short. Head separated from the thorax uniformly in adult animals by a tooth-like projection cephalad. Valves oval, extending into a rather short spine which lies somewhat dorsad of the median, longitudinal axis. Spine and the caudal half of ventral margins of the valves spined; dorsal edge without spines. Shell reticulated by regularly crossing lines. First two anal processes approximate and of equal length. Borders of the anal groove armed on either side with 12 to 14 spines which diminish gradually in size dorsad. Terminal claws without the comb of spines but armed with a continuous series of very fine setæ; on the convex side two small spines. Eye large, with many crystallines; macula nigra point-like. Length 1.20 mm., height 0.70 mm., height of head 0.25 mm., length of spine 0.11 mm.

The male is smaller. Antennule somewhat curved; at the free end it bears, besides the sensory threads, a flagellum, which is somewhat curved at the end and dark contoured at the base and is at least twice as long at the sensory setæ. The lateral seta is situated somewhat separated from the flagellum on the front (cephalic) margin of the antennule. There is the same cervical toothed process seen in the female. Abdominal processes absent. Length of male 0.78 mm.; height 0.42 mm.

It would appear that Forbes *D. dentifera* is the American representative of this species. It differs in having the cervical process much

further cephalad, i. e., over the base of the antennæ rather immediately in front of the heart. The beak in *D. dentifera* does not turn ventrad but caudad.

* **Daphnia dentifera** Forbes.

PLATE LIII, FIG. 9.

Forbes '93.

Broadly oval, long beaked, species with a large eye, posterior spine high and with a prominent angle dorsally between heart and eye in the male and young female. Head broadly rounded, eye near front margin. Fornices short, forming a prominent angle behind the base of the antennæ. Lower margin of head concave, beak projecting. Eye large with numerous lenses, its diameter more than half the distance from eye to beak. Pigment fleck immediately behind the eye and nearer it than the posterior margin of the head. Head crested, forming above the insertion of the antennæ a rectangular process which in the young may bear two or three teeth. This process is reduced to an obtuse angle in the adult female, disappearing in ephippial individuals entirely. Spine of shell long and slender, one third or one-fourth the length of the shell. Caudal claws smooth, anal spines 13. The two abdominal processes approximate. Length of female 1.8 mm. Male 1.0 mm. Very near if not identical with *D. dentata* Matile. This species differs from *D. minnehaha* chiefly in having smooth claws.

Daphnia longiremis Sars.

A species of moderate size and very hyaline. Head small and rounded, ventral margin somewhat concave, beak sharp, directed ventrad. Shell oval, spine short, straight, inclined dorsad. Antennæ relatively long, extending to caudal margin of shell. Post abdomen similar to that of *D. longispina*. Macula absent. Eye small. Length 1.6 mm. Apparently a pelagic form. We are not certain that it represents an adult.

* **Daphnia magniceps** Herrick.

The peculiar form figured in the tenth annual report of this survey seems indubitably new and is distinguished by the peculiar shovel-shaped head, which is scarcely crested but is broadest beyond the middle. The spine is long, the claws smooth, the abdominal processes united and the shell transparent. The eye is near the end of the rounded head and is large; the pigment fleck was apparently absent. Found with *Daphnia minnehaha* in a shallow swampy pool in autumn.

Daphnia cucullata Sars.

Kurz (vitrea).

Very like the above, but the margin of head is not straight below, is, however, extremely variable and ends in a sharp angle. The eye lies nearly midway between the heart and the end of the head and near the lower margin. The two anterior processes of the abdomen are united for most of their length. Anal teeth five to seven. Claw ciliate. The flagellum of the male antenna is about as long as the terminal setæ.

D. apicata Kurz seems to be a large variety lacking the sharp spine of the head. In the main it agrees quite well. Although the post-abdomen is broader than figured by Mueller, the number of teeth corresponds with Sars' description.

Length 0.95 to 1.11 mm.

* **Daphnia kalbergensis** Schoedler.

Plates XXVII, Figs. 1-3; LIII Figs. 5-8.

Schoedler (cœderstrœmii, and berolinensis); Forbes (retrocurva).

Rather delicate species of moderate size, inhabitants of clear and deep waters. Form oval, with a long nearly straight spine springing from near the middle of the posterior margin. Head very large and produced into an enormous helmet-like crest, which projects cephalad and may be somewhat or greatly curved dorsad. The size of the crest and its form are very variable even in the same gathering. Eye small, with few lenses, distant from the ventral margin, macula wanting. Antennæ weak. Post-abdomen narrow, with from six to twelve anal teeth; claws weakly ciliated. Abdominal processes discrete.

As above stated, the close association of forms in the same gathering ranging from *D. vitrea* to the extreme of *D. retrocurva* seems to forbid their separation, even varietally. The case of *D. vitrea* is most open to doubt. The chief differences seem to lie in the small number (4) of anal teeth and the fusion of the two anal processes. A young specimen from Lake Minnetonka had but four large teeth and two inconspicuous ones and the anal processes were less distinct than in older individuals. All transitions could be found. We agree with Hellich that this, at most, is a depauperate variety of *D. kalbergensis*. There seems to be absolutely no good reason for separating *D. cederstrœmii* or *D. retrocurva*, as the differences are largely a matter of age and freedom to develop typically.

P. E. Mueller gives the following measurements for *D. kalbergensis*: Head 0.9 to 1.0 mm., body 1.0 to 1.1 mm., spine 0.7 to 0.75 mm.

Kurz for his *D. ritrea* gives a length of 0.85 mm. plus 0.25 mm., the length of the spine. Judging from his figure, the head would not measure over 0.35 mm.

Forbes says of his *D. retrocurva* that the head is two-thirds as long as the body.

Our specimens measured as follows:

No. 1. 1.6 mm.; head somewhat more than half the body and almost exactly like *D. ritrea* in form.

No. 2. Head 0.6 mm., body 0.9 mm., spine 0.5 mm.; about nine anal spines. Head in this case moderately curved upward.

No. 3. Head 0.95 mm., body 0.95 or less, spine 0.5 mm.; or the head as long as, or, indeed, considerably longer than, the body and directed upward.

The males have the crest much lower, the spine longer, and the form of antennules figured by P. E. Mueller. In the older females the beak is elevated above the antennules, as remarked by Forbes, but in smaller individuals there is very little difference between our specimens and Mueller's figures.

The claws of the post-abdomen have, besides the row of fine teeth mentioned by Mueller, a cluster of sharp teeth just at the base.

Found, together with typical *D. galeata* and the rounded form, in a small deep lake or expansion of a creek not far from Medicine lake, Hennepin county, Minnesota.

We have since found this species at a depth of 80 feet in Lake Minnetonka, and here also in association with *D. hyalina*. The range of variation is exceedingly great as indicated by the figures of Plate LIII.

Having given as full a catalogue of the well known and accessible species as our circumstances now permit, it remains to notice the existence of others which are either imperfectly described or the descriptions are out of reach.

Daphnia similis Claus.

PLATE XXXV, FIG. 5; LI, FIG. 7.

The description of this species, which was bred in confinement from eggs brought in mud from Jerusalem, I am, unfortunately, unable to quote. Judging, however, from the figures which alone I now have access to, it belongs in the group of *D. longispina*, though in many particulars it resembles *D. schæfferi*. The form is elongate, the spine short and springing from the upper margin. The antennule of the female is very large and flagellate, while that of the male is like that of *D. schæfferi*. The flagellum and hook of the first foot of male are rather small.

W. Schmankewitsch described as new *D. degenerata* and *D. rudis*, from salt or brackish waters. These he regards as degenerate forms produced by the inferior aeration of dense waters. The author does not appear to recognize the modern distinctions of genera, so that, not having seen the work, even the generic position cannot be definitely stated. His investigations seem to show that the proximity of salt waters influence the form of the body, or, perhaps, that there is a constant interchange between the sub marine and fresh-water species. *Daphnia brevicauda* Chambers is an incorrectly figured and described *Simocephalus*.

Daphnia bolivari Richard.

Richard '88.

"Caput a latera visum fere triangulare, latum, margine superiore recto; anteriore cum inferiore lineam usque ad apicem rostri æqualiter ac leviter arcuatam formante; rostro acuto brevi. Testa cetera margine dorsali subrecto inter caput et corpus leviter rinuato, margine ventrali aculeato parum arcuato. Spina testæ longa aculeis multis ac validis ornata. In capite a latere viso linea circularis patet insignis distinctissime serie duplo aculeorum acutorum instructa, parte superiore modo lævi. Ad apice dorsali et posteriore hugus lineæ sequitur linea alia eadem structura marginem superiorem testæ usque ad apicem caudalis spinæ. Adest preterea linea alia in medis utriusque lateris testæ, aculeis ornata. Antennæ 1mi paris magnæ. 2di paris mediocres piliis brevibus sed distinctissimis ornatæ. Setæ abdominales mediocres, ad apicem ciliis longis dense obsitæ. Oculus mediocris crystallinis paucis perspicuis; macula ocularis rotunda, parva. Longit. fem. spina testæ inclusa, 3.35 mm., spine, 0.8 mm."

This Spanish species is not sufficiently described to be allotted to its place among its congeners. The armature of the abdomen is absolutely essential.

Daphnia carinata King.

King '52-54.

This form, though incompletely described, will be easily recognized when rediscovered. It belongs to the *D. scahfferi* group and is said to resemble *D. similis* Claus, being one of the largest of the genus. The head is armed with a crest but is depressed and uniformly rounded. The shell is oval with a long spine from the upper angle in the young female. Abdominal processes thick. Post-abdomen attenuated. Details of armature not given. Ephippium with four eggs. The eye is somewhat distant from the margin.

Daphnia gravis Schoedler seems to us but an extreme variation of the above as it was regarded by King.

Daphnia kingii Schoedler is a very large species with the head greatly helmeted. The outline is nearly circular and rises above the level of the back. The shell is oval with an extremely long spine which is directed obliquely dorsad.

Daphina cephalata Schoedler is named from rude drawings by King, which, if they show anything, seem to prove that they represent an abnormality, probably of *D. kingii*. The sac-like distension of the head is at the expense of the lower part of the head.

Daphnia macrura Dana is identified by Schoedler with *D. carinata* King.

Daphnia kisilkumensis Schoedler=*D. vitrea* Uljanin is apparently *D. longiremis* Sars.

Daphnia newportii Baird, from India, is quite insufficiently described but belongs to the *D. schæfferi* group.

Schoedler mentions *Daphnia brasiliensis* Lubbock and *Daphnia granaria* Gay, from Chili.

Haldemann's *Daphnia reticulata* may be *D. pulex* and his *Daphnia abrupta* is *Simocephalus*.

Daphnia lumholtzii Sars.

PLATE LXVI, FIG. 6.

This species from Australia is well characterized by acute depressed frontal spine and the flaring fornices which end in curved spines of considerable length. The male and ephippial female lack the frontal spine but preserve the long spine springing from the upper angle. The antennules of the males are very long and the flagellum two-jointed and about as long as the antennule. The claw of the first foot is greatly developed. The claws have no spines. The anal teeth are 12 or more. Abdominal processes discrete.

FAMILY BOSMINIDÆ.

Small cladocera of remarkable form, due to the great elongation and modification of the antennules, which are seated on a small conical beak-like projection of the ventral aspect of the head and form long, jointed, probosis-like appendages curved in various ways. The shell is laterally compressed and not sharply separated from the body. There is frequently a sharp spine at the caudo-ventral angles of the shell. The surface is reticulate, striate or smooth. Feet, six pairs. The first pair hooked in the male. The antennæ have three and four-jointed rami and are very small. The post-abdomen is truncate and the claw is seated on a considerable prominence. Macula cerebri and cœca absent.

As there is but the single genus [*Bosmina*] we have included generic characters.

These curious animals are often found at great depths in the larger lakes, though they may also occur in weedy localities. They are poor swimmers and rarely caught in the net.

*Bosmina cornuta Jurine.

PLATE LXV, FIGS. 3-5.

Oval, almost spheroidal. Head high, concave below the eye. Beak long, its flagellum midway between the eye and end of beak. Eye large. Antennules curved like a hook composed of 10 or 11 segments. Antennæ as long as the end of the antennules, three-jointed ramus with five setæ, the four-jointed ramus with three setæ. Shell high, greatest height in middle of the length. Back uniformly curved and forming an obtuse angle, with the straight caudal margin. Spines at the caudo-ventral angle short, turned dorsad. Shell hexagonally reticulate. Post-abdomen short, truncate and excavated apically, with two anal spines. Claws finely pectinate. Length 0.4 to 0.54 mm.

*Bosmina longirostris O. F. Müller.

PLATES XLV, FIG. 2; LXV, FIG. 2.

General form oval, shell highest in the middle. Head high, beak short, flagellum arising from near the end of the beak, front protuberant. Antennæ longer than in *B. cornuta*, three-jointed ramus with five, four-jointed with four setæ. Spines of shell short and straight. Post-abdomen short, truncate, unarmed. Claws on a protuberance, pectinate. Length 0.31 to 0.35 mm.

Bosmina longicornis Schoedler.

Very similar to *B. longirostris*, but the front is not protuberant, the flagellum is midway between eye and end of beak. The spines of the shell are long, toothed ventrad and directed obliquely dorsad. Shell unmarked. The finely pectinate claws have at their base several large accessory spines. Length 0.36 mm.

Bosmina brevicornis Hellich.

A large species with depressed head having a uniformly rounded front. Shell higher than long and coarsely reticulate, spine short and curved. The beak is short and little curved, the flagellum being quite near the eye. The antennules have seven segments. The post-abdomen is large without anal spines and the claws are simply pectinate. Length 0.55 mm. Hellich says this differs from *B. brevirostris* P. E. Mueller, which has a protuberant front and long serrate spine and the claws have seven accessory spines.

Bosmina bohemica Hellich.

Body large, slender. Head high, front uniformly rounded, flagellum nearer the end of beak than the eye. Beak short, rounded. Antennules long and arched, composed of 16 or 17 segments. The triangular spine above the sensory filaments large and acute. Shell as long as high, highest in the middle. Spine long, curved dorsad and toothed. Shell irregularly reticulate and longitudinally striate. Post-abdomen large, truncate and excavated. Inferior angle ciliate. Claw protuberance long, unarmed. Claw with six spines at the base. Length 0.6 mm.

Bosmina microps P. E. Mueller.

Oblong, length much greater than height. Front not protuberant. Cando-ventral angle of the shell without the spine, rectangular. Antennules long, nearly straight, flagellum nearly midway between beak and eye. Length 0.5 mm. or less. The shell is reticulate and the antennæ are very short.

Bosmina maritima P. E. Mueller.

Oblong, longer than high, front moderately protuberant. Shell strongly arched above; spine long, directed obliquely ventrad. Antennules slender, gently curved; flagellum near the beak. Shell smooth. Length 0.5 mm.

Bosmina brevirostris P. E. Mueller.

Oblong, length greater than height, front greatly protuberant. Shell arched above, strongly spined. Antennules moderate, straightish but inclined caudad. Flagellum near end of beak, sensory setæ remote. Length 0.6 to 0.7 mm. Color reddish.

Bosmina diaphana P. E. Mueller.

Gibbous, length greater than height, front not protuberant. A slight sinuosity in the dorsal outline over antennæ. Shell very strongly arched without the spine, smooth. Antennules very long, curved, converging at the ends. Flagellum near the end of the beak. Length 0.6 to 0.7 mm.

Bosmina lilljeborgii Sars.

PLATE XLV, FIG. 3.

Very gibbous dorsally, length and breadth nearly equal, front not protuberant. Dorsal outline sinuous over the antennæ. Spine absent. Antennules longer than the body, straight or slightly curved, divergent. Flagellum near end of beak. Length 0.6 to 0.75 mm.

Bosmina curvirostris Fischer.

Body rounded, length little greater than height, front somewhat protuberant, dorsal margin strongly arched, antennules short and strongly curved. Flagellum midway between eye and end of beak. Seven to eight setæ upon the cephalic aspect of antennæ. Length 0.39 to 0.4 mm.

* **Bosmina striata** Herrick.

PLATE LXV, FIG. 1.

Herrick '82.

This form is very imperfectly known, but resembles *B. bohemica* and may be identical, but that is a much larger form. Oblong, slender, greatest height cephalad of middle, front strongly arched. Eye large. Flagellum near the beak. Antennules very long, curved. Shell irregularly marked with anastomosing longitudinal lines producing a deformed reticulation. Spine large, curved, but not long. Ventral margin sinuous, ciliated cephalad. Length 0.25 mm.

* **Bosmina atlantaensis** Turner.

This is not adequately described. It, however, affords proof of the existence of a fourth type of *Bosmina* in America. *B. longirostris*, *B. cornuta* and *B. striata* all have the shell marked and peculiarities of structure otherwise. The southern form has a smooth shell, long antennules, depressed spine, sinus between head and body, and flagellum nearer to the eye than to the sensory setæ. The post-abdomen is broad and the claws toothed. The whole genus requires revision.

Other species which cannot now be placed are the following:

B. gibbera and *B. rotunda* Schoedler.

B. læris Leydig, probably the young of *longirostris*.

B. londensis Norman and Brady.

B. obtusirostris Sars, probably is *B. brevirostris*.

B. lacustris and *B. nitida* Sars.

B. coregoni Norman and Brady, is *B. lilljeborgii*.

B. macrorhyncha, a species from the Nile.

FAMILY LYNCODAPHNIDÆ Sars '61; Herrick '81.

This is a rather small family with several genera of minute animals which are abundant only in summer. Many, and indeed most, of the species are among the rarer of fresh water crustaceans of this group, and a few are among the rarities which only now and then reward the

collector. This family undoubtedly is the link connecting the *Daphnidæ* with the *Lynceidæ*, relationships to which are expressed by *Macrothrix*, on the one hand, and *Lyncodaphnia* on the other.

The rank of this group as a family must be, of course, a matter largely of opinion. Sars was the first to adopt this view, sustained by certain curious transition forms leading toward *Lynceidæ*. Later writers seem never to have found these genera and the group was again included with the *Daphnidæ*. The writer ('82), upon the discovery of the *Lyncodaphnia* was forced to regard this group as of equivalent grade with the above mentioned families and again proposed the family name *Lyncodaphnidæ*.

The genus *Ilyocryptus* is a little one side the normal course of the family and seems related to the lynceid genus *Leydigia*.

The waters of the northern United States are very rich in members of this family.

The aberrant family *Bosminidæ* finds its only connection with other *Cladocera* through this group by means of the remarkable *Macrothrix* (?) pauper; and here it is only vaguely hinted at in the elongated antennules and angled lower margin of shell, as well as the presence of certain bodies near the base of the antennules. It has been affirmed that none of the *Lyncodaphnidæ* have an ephippium, i. e., the saddle-shaped thickening of the shell walls to include and protect the winter eggs; but I have discovered it in the case of *Macrothrix tenuicornis* Kurz and presume it may occur exceptionally in others. Kurz says that *Ilyocryptus* has no moult proper, but this probably refers only to the European *I. sordidus*. The American species differs from the generic description given by Kurz, and may be different in this respect also.

In this family the regularity in the disposition of the setæ on the antennæ is broken and the fringing of these hairs serves the purpose of specific distinction. The antennules are always long and frequently differ considerably in the sexes. The pigment fleck is always present (Kurz is in error in denying its existence in *Lathonura*). In many forms there is no free posterior margin of the valves, while the lower is generally thickly beset with movable spines. The *Lyncodaphnidæ* will be distinguished from *Ceriodaphnia*, which they resemble, by their motion, which is a succession of quick bounds, while the broader *Ceriodaphnidæ* hobble along as though heavily weighted by the enormous mass of eggs with which they are generally laden. The abdomen is usually short and the anus is behind the terminal claws, but in *Ilyocryptus* the claws are long and spined at the base. In the American *I. spinifer* the anal opening is elevated to a point nearly underneath the stylets, and there is a rudimentary anal cæcum as in *Lynceids*.

The males have the opening of the vasa deferentia in front of the claws, which may be absent; the antennules are also modified, being longer and curved. In *Lathonura* the abdomen is elongated posteriorly till it begins to suggest a transition to *Polyphemus*.

The known genera and their distribution is as indicated below. Half of the known species are found in America, one-fourth being peculiar to it.

Genera.	Total Number of Species.	European.	Also American.	Only in America.	Total American.
Macrothrix	4	3	2	1	3
Lathonura	1	1	1	.....	1
Drepanothrix	1	1	.....	.....	.....
Streblocerus	1	1	.....	.....	.....
Acantholeberis	1	1	.....	.....	.....
Ofryoxus	1	1	1	.....	1
Lyncodaphnia?	1	.....	.....	1	1
Hyocryptus	3	2	.....	1	1
Totals	13	10	4	3	7

GENUS MACROTHRIX Baird.

Body oval, pointed behind; head broad; antennæ of first pair long, nearly straight, beset with spines, olfactory threads terminal; swimming antennæ large and powerful, propelling the animal by bounds; three-jointed ramus with a greatly elongated setæ which is thorned and jointed; labrum with the basal joint enlarged, resembling that of *Lynceids;* first foot with a hook in both sexes; last foot with a long process (respiratory body); abdomen short; claws short; caudal stylets often with a bush of hairs at tip. The intestine is straight and without cæca in front or behind.

The first one to observe a member of this genus, apparently, was O. F. Müller whose *Daphnia curvirostris* is usually referred to *Macrothrix laticornis*.

The name *Echiniscu* was proposed by Lievin, but *Macrothrix* was applied by Baird in 1843. Four species are known, three of which occur in America, and without doubt the fourth will ultimately be found. No males of this genus were known till 1877 when the male of *M. laticornis* was described and figured (Grube and Weismann '80.) Nearly two years later the male of *M. rosea* was described from Wisconsin by E. A. Birge. Descriptions of the male of *Lathonura* are also given in both the above mentioned sources.

*Macrothrix laticornis Jurine.

PLATES LIV, FIGS. 9-12; LVI, FIGS. 8, 9.

Jurine '20; Baird '50; Fischer '52 (Daphnia curvirostris); Lilljeborg '53; Schoedler '58; Leydig '60; Norman and Brady '67; P. E. Mueller '68; Lund '70-'71; Fric '72[1]; Kurz '74; Herrick '84; Birge '91.

This ubiquitous species was first reported in America by Birge though it had been encountered by the writer in several instances. It is recorded at Madison, Wis., Minneapolis, Minn., where it is not rare, and in Albuquerque, New Mexico.

The body is compactly oval, with a curved or subangular lower margin which is armed with spines which project in three planes, thus producing three series; dorsal margin convexly arched, crenulate or subdentate. Head short, produced ventro-cephalad to form a blunt beak from which the antennules are suspended. Eye of moderate size; pigment fleck large; quadrate. Antennules short, greatly expanded at the tip, provided with the usual sensory setæ and flagella and a cluster of spines at their bases, also a second cluster upon a special protuberance posteriorly. Upon the anterior margin are series of bristles and this margin is serrate. The antennæ are strong, hairy, and armed as usual in the genus. The feet are sufficiently represented in the figures. The post-abdomen is short, with very small terminal claws, in front of which are several bristles not previously noticed; about the anus are several bristles, and a series of short teeth ornaments the dorsal margin. The whole shell is hexagonally reticulate except along the dorson where the slight crest modifies the markings. Length 4.7 to 6.0 mm. Birge found this form only rarely and then singly. Fric speaks of it as loving the bottom and occurring singly. We have frequently found it in Minneapolis and abundantly in New Mexico.

As the type of the genus, it appropriately occupies a conservative position, as shown by broad tip of the antennules, a feature exhibited by embryos and young of other species.

*Macrothrix nova-mexicana sp. n.

PLATE LIX, FIGS. 3-5.

Testa corporis suboblongata, levis, postice non angulata, marginalibus ventralibus æqualiter rotundatus fere rectus, ciliatas gerentibus. Oculus magnus; macula cerebralis parva sed manifesta. Antennæ fere rectæ, ad apicem versus paulum dilatatæ, posticæ ciliatæ. Antennæ 2-di paris illæ *M. rosea* similes. Cauda brevis, apice rotundato, super anum sinuata, ad apicem versus densa ciliata, margine cetero seribus setarum minimarum armato sive inermis. Longit 1.1 mm.

As compared with *M. rosea*, its nearest ally, this form is not only considerably larger (the largest figures being 0.9 mm. in length by 0.6

mm. high, while the present form measures 1.1 by 0.7 mm.) but the form and several details noticeably differ. The shell, as seen from the side, is nearly quadrangular, reminding of *Lathonura*, and is not produced into a sharp spine as in *M. rosea*. The head is also shorter and is not excavated between the eye and pigment fleck. The ventral margin of the valves is not obviously sinuous and is spinulus as in *M. rosea*. The antennules are straight, and not strongly curved, as figured by Kurz, neither are they spiny in front. At the tip they bear the usual sensory setæ and posteriorly a cluster of spines while the posterior margin is ornamented with several clusters of bristles distally. The antennæ seem not to differ materially from those of *M. rosea*. The post-abdomen is shorter than in *M. rosea*, its terminal claws are small, curved, deep-colored and unarmed; in the protuberance formed by the anus are closely clustered spines and bristles while the rest of the margin is either unarmed or furnished with a few minute spines. The long stylets are as usual in the genus. No markings were seen on the shell. Projecting into the brood-cavity are two leaf-like plates which seem to serve an accessory branchial function and contain many blood corpuscles. Details of the feet are wanting. The species has been but once seen, in the clear water of the tank supplying Albuquerque, New Mexico, accompanied by two species of *Diaptomus* and a *Moina*.

M. rosea occurs in the north, often in considerable numbers (Birge '91) and the present species may take its place to the southward. It may be admitted that it approaches *Lathonura* more than any other species of the genus.

It is just brought to my notice that Matile describes in an appendix to his paper "Die Cladoceren der Umgebung von Moskau, 1891," *Macrothrix borysthenica*, which is so very close to our species that we suspect intimate comparison will prove the two identical. The antennules in Matile's species are shorter and the dorsal margin is less strongly marked. The armature of the post-abdomen is perhaps slightly different but our description was drawn from very large individuals and considerable variation was observed. I therefore withdraw the name proposed for the present.

Macrothrix hirsuticornis Norman and Brady.

Norman and Brady '67; Daday '88; Matile '90.

Head separated from the thorax by a depression. Shell roundish, caudal angle obtuse, smooth, ventral margin gently rounded. Antennules dilated toward the end, slightly curved, cephalic margin with five series of small setæ. Post-abdomen rounded at the end, having distally seven setæ and proximally small teeth. Length 0.55 mm.

Macrothrix serricaudata Daday.

Shell rounded, punctate, transparent, obtusely angled caudad. Caudal part of dorsal margin serrate, ventral margin nearly straight, sparsely ciliate cephalad. Antennules long, subcylindrical, attenuate at the end, slightly curved, armed with minute setæ. Post-abdomen rounded at the end, sinuous above the anus, serrate with strong teeth. Length 0.9 to 1.0 mm. This species is near to our own *M. pauper*.

* **Macrothrix rosea** Jurine.

PLATES LIV, FIGS. 1-3; LVI, FIGS. 5-7, 11, 13.

Monoculus roseus—Jurine.
Lynceus roseus—Desmarest.
Daphnia rosea—M. Edwards, Jurrell.
Echinisca rosea—Lievin.

The body is sub-oval, terminating behind in an acute angle; the lower margin is less conspicuously spined than the last or the following; the antennæ are but slightly dilated at the end and nearly straight. The longest seta of the antennæ is longer than in the last, reaching beyond the tips of the terminal setæ; abdomen more slender, sinuate in front, beset with short hairs.

Length 0.6 mm., male 0.3 mm. The male has small claws on the end of the post-abdomen, and the antennules are curved and elongated.

In a later publication Birge finds small claws on the post-abdomen of the male which resemble that of *Bosmina*. On the posterior side of the apex of the antennules of the male is a cluster of five or six long sense hairs peculiar to this species.

* **Macrothrix tenuicornis** Kurz.

PLATES LIV, FIGS. 5-8; LVI, FIGS. 1-3, 12, 20.

(See Notes on Cladocera of Minnesota, p. 245.)

The body is oval, produced posteriorly in a sharp point; the abdomen is strongly arched, while the upper outline of the head is a regular curve or slightly extended in front of the eye; the antennules are long, nearly straight and a very little narrowed toward the end, just in front of which is a series of short teeth; there is no lateral spine, but a strong terminal one in addition to the sensory filaments; the pigment spot is large, the eye small and the lobus opticus well separated from the ganglion; the antennæ have a very powerful basal joint; the elongated seta is very stout and densely spiny, with a tooth at its flexure; two of the terminal setæ are spiny, for the basal half; the valves are beset with very long spines in sets of three each, all having different positions; the abdomen is nearly as in *M. rosea*, but

the posterior margin has a series of long sharp teeth; the mandibles are nearly completely exposed by the arched anterior margin of the valves.

The labrum, in this species, is an odd link between that of the *Daphnidæ* and *Lynceidæ*. The basal segment is greatly enlarged and is sub-triangular in outline, with a movable lip attached to the inner free face; the typical daphnoid structure is preserved, but the enlarged salient angle of the basal portion shows how the transition to the great triangular labrum of *Alona*, etc., is made. In young specimens the head is proportionately larger, the antennules are broader at the tip, and the dorsal outline is less convex: the marginal spines of the valves are also proportionally larger, as are the appendages of the first and last pairs of feet. This is one of the largest species of the genus, 0.75 mm. being the length. This is very close to *M. rosea* but seems distinct.

This form is quite common about Minneapolis, Minn., but is not yet noted elsewhere in America.

*Macrothrix pauper Herrick.

PLATE LVI, FIG. 4.

This species is described from a single specimen from Lake Minnetonka, and I can add nothing to the very meager notice given then. (Herrick '82.)

The body is broad and very narrow, the lower outline is angled and nearly unarmed; the pigment fleck and eye are small and approximated; antennules very long and curved backward and outward; abdomen short, ciliate below; claws short, ciliated. This female had a full complement of eggs but the antennæ resemble those of a male. This is unusually interesting and should be rediscovered and studied; for there seems to be some affinity between this species and *Bosmina*, and it is probable that it requires to be distinguished generically from *Macrothrix*.

GENUS LATHONURA Lilljeborg.

The form is oval; the head is curved more than in *Macrothrix* and the shell is more obtuse behind, sinuate below where it is beset with short spines anteriorly; first antennæ long, straight; second antennæ with five setæ on each ramus; only four pairs of feet apparent; abdomen short, prolonged upward to the insertion of the caudal stylet; male similar but smaller.

*Lathonura rectirostris O. F. Müller.

PLATE LVII.

Koch '35-'41 (Pasithea rectirostris); Zaddach '44 (Daphnia brachyura); Lievin '48 (Daphnia brachyura); Fischer '52 (Daphnia mystacina); Lilljeborg '53; Leydig '60 (Pasithea rectirostris); Norman and Brady '67; P. E. Mueller '68; Schoedler '58 (spinosa); Birge '78; Gruber and Weismann '80 (Pasithea rectirostris); Herrick '82.

The only species of the genus is distributed probably over the entire northern temperate zone. It has been found in America at Cambridge, Mass., and in the vicinity of Minneapolis, at both of which places it is very rare.

The form is a rather quadrangular oval, the head being strongly arched to the beak which is much farther posterior than in *Macrothrix*, in this respect resembling the *Daphnidæ*: the eye occupies the center of the lower part of the head margin, and is of moderate size; the pigment fleck is near the base of the antennules and well removed from the eye; the antennæ are straight and long, with a sensory bristle near the base in front and two bristles a third from the end; the second antennæ are furnished with a powerful basal joint, while each of the main subdivisions of the rami has its bristle, which are nearly equal; two of the terminal setæ are toothed for the basal half and pectinate distally, but the others are feathered throughout; the four-jointed ramus has a spine on the second joint and a longer one at the end, and all the joints of both rami are ornamented with triple series of spines; the maxillæ are three spined at the end and are in almost constant motion; the first pairs of feet have curious comb-like bunches on some of the setæ; the abdomen is very short and terminates in inconspicuous teeth, the posterior part of the abdomen being ornamented with teeth flattened longitudinally so as to look like spines from the side; the last foot is simple but bears a large appendage; the posterior third of the shell is fringed by extremely minute spines, but anteriorly by lanceolate stiff spines flattened longitudinally like the spines of the abdomen; the caudal setæ are seated on a high prominence of the abdomen, and are fringed along their whole length, not merely at the end. The female is 1.0 mm. long, the male 0.5 to 0.6 mm., in which sex the antennules have more numerous lateral bristles, the first foot has a claw and the back is less elevated. The semen bodies are irregularly round with small nuclei.

GENUS STREBLOCERUS Sars.

In form like *Macrothrix laticornis*, head terminating in a long rostrum bearing the long, twisted antennules. Antennules very large, curved backward and outward. Head not separated by a distinct

depression from the body, very high, slightly arched above, abruptly curved below with spines upon the margins. The antennæ are large; four-jointed ramus much the longer, with four setæ. Labrum with a large process. Post-abdomen much as in *Macrothrix laticornis*, serrated or notched behind. Eye near the beak; pigment fleck small, situated below the eye at the base of the antennules.

The shell is hexagonally reticulate, arched above and angled below; ventral margin armed with rigid spines. Claws ciliate. Length 0.34 to 0.4 mm.

Our *Macrothrix pauper* seems a near approach to this genus; both have a strong spine or claw on the first foot which projects beyond the shell, but there are many differences. *M. pauper* is 1.0 mm. long.

S. serricaudatus Sars (Plate LXVI, Fig. 1) is the only species.

GENUS DREPANOTHRIX Sars.

The head separated from the valves by a depression; fornices moderate; rostrum rather acute, distant from the anterior edge of the valves. The form is subrotund; reticulate, with the margins of shell fringed below by long movable spines; pigment fleck present; swimming antennæ with three ciliated setæ on the four-jointed ramus, the three-jointed ramus with its basal joint armed with an unjointed, strong, spinous seta and four ciliated setæ on the remaining joints. The post-abdomen is broad. Intestine coiled. The male has longer antennæ and a hook on the first foot.

Drepanothrix dentata Euren.

Plates XLVI, Fig. 9; LIV, Fig. 4; LVI, Fig. 14.

Acantholeberis dentata—Euren.
Drepanothrix setigera—Sars.
Drepanothrix hamata—Sars.

* Drepanothrix hamata Norman and Brady.

This animal is only 0.5 mm. in length. The antennules are laterally curved in the middle and ornamented with notches on the margins; the pigment fleck is quadrate and rather large; the post-abdomen is truncate at the end, convex behind and ornamented with a series of small spines. Shell margins with long spines.

Birge reports this species from Lake Wingra near Madison, Wisconsin. It seems to be repelled by light and is a bottom-loving form. Though it swims fairly well, the stiff setæ are chiefly used as pushing poles. The species has been taken in Denmark, Scandinavia, England and France as well as America.

GENUS ACANTHOLEBERIS Lilljeborg.

Body more or less quadrangular, head triangular, acute cephalad, bearing the antennules at the front. Fornix slightly developed. Head scarcely separated by a depression from the body. Antennules elongate, expanded apically. The three-jointed branch of the antennæ has five setæ, the four jointed ramus has three, all being apical. The seta of the basal joint of the three jointed ramus is elongate. Labrum with an acute process. Feet six pairs. Intestine with a loop. Post-abdomen broad, armed with a series of spines. Margin of the shell with long spines below.

Acantholeberis curvirostris O. F. Müller.

PLATE XLVI, FIGS. 1-4.

O. F. Müller 1785 (Daphnia curvirostris); Schoedler '46 (Acanthocercus rigidus); Lievin '48 (Acanthocercus rigidus); Lilljeborg '53, and '58 (rigida); Leydig '60 (rigidus); Norman '63; Norman and Brady '67; P. E. Mueller '68; Lund '70-'71; Hellich '77.

This rare species has not yet been found in America but may be confidently expected. The aspect is macrothroid, the whole ventral margin being long ciliate, while from near the posterior angle arise a number of greatly elongated setæ. The caudal margins are armed with short spines. The macula is present but rather small. The antennules are elongate, expanded toward the tip, somewhat curved and armed apically with about eight unequal lanceolate processes and smaller spinules. The post-abdomen is broad, rounded distally. The claws have two small basal teeth and a series of small setæ. The posterior margin is armed with a series of small teeth. Length less than 1.5 mm.

GENUS OFRYOXUS Sars.

Lyncodaphnia—Herrick.

Body elongated, somewhat rectangular as seen from the side, greatest width and height of shell a little posterior to the heart; head separated by a depression from the body, truncate below; antennæ and antennules much as in *Macrothrix:* four jointed ramus of antennæ with no lateral setæ: eye small, pigment fleck present; intestine twice convoluted, expanded posteriorly, with anterior but no posterior cæca, opening near the "heel" of the post-abdomen; post-abdomen large, triangular; terminal claws long, rather straight, with two accessory spines at the base.

Ofryoxus is, as was suggested, a curious transition form linking the *Daphnidæ* with the *Lynceidæ*.

O. gracilis not only has the disc like last foot colored but the swimming antennæ are banded with purple as in *Simocephalus rostratus* Herrick and *S. americanus* Birge. The intestine has anterior cæca, which is not the case in *Lyncids*, nor, indeed, in other *Lyncodaphnidæ*.

The four-jointed ramus of the antennæ approaches *Lyncidæ* in the absence of a lateral seta, but the other ramus is as in *Macrothrix*. The convolution of the intestine, the form of the post-abdomen and the situation of the anus are all of a strictly lynceid type; moreover, the flattened appendage of the last foot is like that of *Eurycercus*.

Even in the form of the shell there is a combination of characters; the anterior part of the shell has the form peculiar to *Lyncodaphnidæ*: but posteriorly it again expands and becomes truncate behind; the form in the adult is not unlike that of some *Lyncidæ*, but the young has a long spine posteriorly exactly like the spine of *Daphnia*. The latter fact is very instructive, for it indicates that the theory proposed (American Naturalist, 1882, p. 815) to explain the origin of this appendage is probably the correct one. Professor Leuckart suggested that this spine was a balancing rod intended to keep the proper equipoise over the center of gravity; but it is difficult to see why these long-bodied forms, in which the greater part of the weight lies "abaft" of the pivotal point—the base of the antennæ—should be thus provided while the shorter forms are not. We conceive that it is an apparatus for effecting the moult of the inner lining of the brood cavity of long-bodied and tender-shelled animals such as *Daphnia* and the present genus. The great development of the head in the crested *Daphnidæ* may undoubtedly be explained upon Professor Leuckart's theory.

* Ofryoxus gracilis Sars.

PLATES XLII, FIGS. 12-15; LVIII, FIGS. 1-3; LIX, FIG. 2.

Herrick '82 (Lyncodaphnia macrothroides).

Sub-rectangular, greatly elongated, truncate behind, with a slight spine above; head and eye small, fornix moderate, beak truncate; antennules rather long, slightly curved, tapering a little toward the end, whence spring three lanceolate spines and several sensory filaments, five stout spines behind, above the middle, and several more slender ones; swimming antennæ very long, terminal setæ smooth to the joint; labrum as in *Daphnia:* mandible attached behind a salient angle of the front margin of the shell; no abdominal processes; post-abdomen broad above, triangular; terminal claws pectinate, furnished with one very large toothed accessory spine and a smaller one; the first foot has a hook; the last foot consists of a large oval plate which bears poste-

riorly the ordinary branchial coil, here shaped like a thumb and forefinger. The young is of a different shape and bears a long spine. The male is known from figures recently published by Birge ('91).

GENUS ILYOCRYPTUS.

Form compact, short; head short, triangular, with large fornices forming a roof over the head; the posterior margin of shell nearly as long as the inferior; lower angle a broad curve; antennules two-jointed, basal joint very short, second joint straight, rather long; setæ terminal, but one seta near the base; the four-jointed ramus of the antenna with but three (terminal) setæ; six pairs of feet, last pair rudimentary; tail large, as in *Lyncodaphnia*, anus elevated; intestine straight, without cæca, but an expansion near the rectum sometimes simulates one; the margin of the shell is bordered with long spines, which may be branched or simply pectinate. There is often, perhaps generally, a failure to entirely remove the moulted shell; when this occurs the newly-formed shell from each moult remains under the older ones till the animal seems to be wearing six or more overcoats, and the spaces so formed become filled with algæ and filth till the animal is no longer able to swim. P. E. Mueller and Kurz, who seem to have seen only *I. sordidus*, agree that *Ilyocryptus* cannot swim, but poles along in the mud on the bottom by means of antennæ and abdomen; our *I. spinifer*, on the other hand, swims freely till loaded up with old clothes and filth.

This genus is also closely allied with the *Lynceidæ*.

* Ilyocryptus sordidus Lievin.

PLATES LV, FIGS. 6, 10, 11; LVI, FIGS. 15-17.

Acanthocercus sordidus—Lievin, Leydig.

Body higher than long; head small, terminating anteriorly in almost a right angle; posterior part of the shell margins covered with branching, thorny spines; antennules cylindrical; antennæ short; four-jointed rami with no lateral setæ; post abdomen large, broad; terminal claws with two spines at the base; anus in the middle of the posterior margin, which is very heavily armed with spines; a hairy abdominal process is present, according to Kurz.

There are no anterior cæca (my statement that P. E. Mueller described such cæca was an error; see Notes on Cladoreca of Minnesota, p. 246). Length 0.78 mm. The tabulated comparison beyond makes a full description unnecessary. Birge reports this species from Wisconsin and it has been encountered in Minnesota.

* Ilyocryptus spinifer Herrick.

PLATES LV, FIGS. 1-4; LVI, FIGS. 18-19, 21.

Herrick '82, '84, and '87; Turner '93.

The description given in my Final Report, etc., is very brief, and no comparisons were there instituted with the *I. agilis* of Kurz, which is its nearest ally in Europe. The paper by Kurz referred to gives detailed descriptions of the three European species, accompanied by elegant plates. We are able, therefore, to draw up the following distinctive diagnosis of the species, hoping thereby and by means of the figures to show the relations of the four species at present known. It is almost certain that we have more than one species in America, and the careful description of the known form may make the detection of others easier.

The size varies greatly; a full grown female with eggs in the brood cavity is nearly 0.90 mm. long and 0.70 high, while a smaller female measures 0.65 mm. long by 0.44 high. The form of the shell is nearest like that of *I. acutifrons*, the height being less than in *I. sordidus*, and the angle between the ventral and posterior margins less than in *I. agilis*. The entire length of the post-abdomen in the large female is 0.56 mm. measured to the base of the caudal stylets, of which length 0.168 mm. pertains to the claws. The width of the post-abdomen is but 0.14 mm. Thus it is evident that the proportions of the post-abdomen differ greatly from any of the other species, it being very long and narrow. The terminal claws are exactly as in *I. agilis*, having two small basal spines and a few sharp serrations near the apex, anteriorly. Near the base of the claw is a cluster of small spines of two sizes, then begins a series of about 16 lateral teeth averaging 0.02 mm. in length and extending to the sides of the anus. Above this point the contour of the margin is convex and is ornamented with nine spines twice as long as the preceding. Then follow the prominences which bear the long and simple caudal setæ. Besides the above mentioned spines there are four spines on either side upon the lower posterior angle of the post-abdomen which are four times as long as those of the previously mentioned continuous series (i. e., 0.08 mm.). Above, the abdomen is hirsute or thorny as in *I. agilis*, and the process for closing the brood sac is similar. It will be seen that the post-abdomen differs in armature as much as in form from other species. From *I. sordidus* it differs in the following points: The claws are not pectinate behind but are serrate in front, the anal opening is higher and the details of the spines vary; from *I. acutifrons* it differs in that the claws are not pectinate, neither is there a spine in front of the claws, and the anus is not terminal; from *I. agilis* it differs in that the shape is different, there are fewer enlarged spines, and the

shape of the nine spines above the anus is different. The head is convex, resembling *I. sordidus* most nearly, but the antennules are much longer and more slender than in any other known species. They are 0.17 mm. long and about 0.016 mm. wide, while the longest seta is 0.084 mm. long. The antennæ are almost exactly as in *I. sordidus*. The labrum has the usual shape, as have the jaws and other appendages. The margins of the shell are ornamented with spines simply pectinate or barbed as in *I. agilis*. In *I. sordidus* these spines are variously branched, and in that form alone of the European species, according to Kurz, is there a failure to perfect the moult; in our species, which has simply pectinate setæ, the old coverings are all but uniformly retained. The spines of the lower posterior margin are from 0.16 mm. to 0.20 mm. long.

Such are some of the chief peculiarities of the species, but, to make the relation between the four species of this little known genus even clearer, if possible, the following comparative table is appended.

The shell moulted periodically	*I. agilis.* *I. acutifrons.*
The shell not moulted but retained	*I. sordidus.* *I. spinifer.*
Antennules not more than eight times as long as broad	*I sordidus.* *I. agilis.* *I acutifrons.*
Antennules more than eight times as long as broad	*I. spinifer.*
Claw of post-abdomen pectinate	*I. sordidus.* *I. acutifrons.*
Claw of post-abdomen not pectinate	*I. agilis.* *I. spinifer.*
A strong spine in front of claw	*I. acutifrons.*
Fine bristles or none in front of claw	*I. sordidus.* *I. agilis.* *I. spinifer.*
Anus opening near the claws	*I. acutifrons.*
Anus about midway of the posterior border	*I. sordidus.* *I. agilis.* *I. spinifer.*
Marginal spines of shell much branched	*I. sordidus.*
Marginal spines nowhere much branched	*I. agilis.* *I. acutifrons.* *I. spinifer.*
Elongated anal spines on either side, four or five, very long	*I. spinifer.*
Elongated anal spines more numerous	*I. agilis.* *I acutifrons.* *I. sordidus.*
Upper (one to three) spines of the supra-anal series modified and enlarged	*I. acutifrons.* *I. agilis.*
Upper spines like the others	*I. sordidus.* *I. spinifer.*

The above is extracted verbatim from the Alabama Crustacea, which Professor Birge should have consulted before saying "none of the specific characters are mentioned or figured" (Birge '91).

Professor Birge is inclined to identify our species with *I. longiremis* Sars, from Australia. But if the Madison specimens have antennary setæ nearly equaling the total length of the animal, they differ from all individuals of *I. spinifer* yet seen. The armature of the post-abdomen is also different, for there are but four elongated claws at the inferior angle and a series of about 14 anal spines and six longer supra-anal teeth. We infer from Birge's figure that the antennæ are different. It would be well that the Madison form should be more carefully described and figured and compared with other American species. Length 0.60 mm., height 0.46 mm., base of antenna 0.19 mm., four-jointed ramus 0.13 mm., post-abdomen 0.19 mm., claw 0.125 mm., long post anal spines 0.06 mm., antennule 0.10 mm.

Ilyocryptus acutifrons Sars.

PLATE LV, FIG. 7.

This species is only mentioned in the appendix to the paper of Sars on the *Cladocera* from the vicinity of Christiania. The following is a condensation of the description.

Head large, acute in front. Shell truncate behind, with shorter setæ behind than below. Antennules shorter and thicker than in *I. sordidus*. Antennæ long and robust. Abdomen with a short, obtuse process. Post-abdomen shorter than in *I. sordidus*, posterior margin continuous, anus terminal; caudal claws straight, very long, with two minute basal spines and a cluster of teeth in front. Pigment fleck almost touching the eye. Length less than in *I. sordidus*, 0.6 mm.

In this species the moult is perfect. (See table above.)

* **Ilyocryptus longiremis** Sars.

PLATE LV, FIG. 5.

Sars '88; Birge '91.

Professor Birge finds this species abundant near Madison. The original description is not now accessible. It appears, however, that the form of the post-abdomen is very similar to *I. spinifer*, while its armature is quite different. The setæ of the antennæ are very long, nearly equaling the length of the body. There are five to seven super-anal teeth, largest in the middle, an outer row of about eight long post anal spines and an inner row of 11 to 12 post-anal denticles, besides several very small teeth near the terminal claw. There are three or four denticles on each side of the anus. The moult is incomplete as in *I. spinifer*.

FAMILY LYNCEIDÆ.

This family, which is numerically the largest among the *Cladocera*, is, in the main, well limited, though there are transitions toward the *Lyncodaphnidæ*, which are quite direct. The genera *Lyncodaphnia*, *Ophryoxus* and *Ilyocryptus* lead toward the *Lynceidæ* unmistakably. Most of the members of this family are small, comparatively few exceeding one millimeter in length. The head is covered with an arched shield, which frequently passes with no indentation into the shell of the body. This head covering generally extends forward and downward to form more or less of a sharp angle in front, while in several genera it is simply rounded in front. It, in either case, arches over the more fleshy lower side of the head from which hang the two short antennules and the labrum, while the strong two-branched antennæ spring from well up under its posterior expansion. The rounded sides of this shield, which protect the insertion of the antennæ, are called the fornices. Above the insertion of antennules is a dark fleck lying near or on the lower angle of the brain; this is the larval or nauplius eye, which is the first to appear in all these small crustacea. This *macula nigra* is not infrequently as large as the eye itself,* or even larger, and in one genus it is the only visual organ. The antennules are small and bear on the end several sensory filaments as well as a lateral flagellum. The antennules of the male differ very little from those of the female. The labrum is furnished with a process, which is triangular or semicircular and is usually larger than the terminal portion. The mandibles are as in *Daphnidæ* but usually shorter. Maxillæ are often conspicuous, but the first pair of feet serve, by a slight alteration at the base, the same purpose. There is rarely an indication of the sixth pair of feet, and the antennæ have both rami three-jointed. The terminal part of the body, or post-abdomen, is usually enlarged, and the anal opening is near its base; the armature is usually considerable. The form of the post-abdomen is one of the best criteria for distinguishing genera and species—a process often attended with much difficulty.

The shell is of various forms, frequently beautifully sculptured. The number of eggs produced at one time is limited, and the winter eggs are very often laid in the brood-cavity with no preparation of the shell previous to it; in other words, the ephippium may be absent. On the other hand, sometimes the shell is considerably modified, and generally there is a deposit of dark pigment in the upper part of the shell. The males are very rare and until recently few were known. The diligence of Kurz has added a great many, and we now have a

* The name "Lynceus" is derived from that of the son of Aphareus who was famous for the sharpness of his vision.

fair idea of the sexual variations. These consist usually in a narrower body and shorter beak, in a strong hook of chitin on the first foot and certain modifications of the post-abdomen. The hook mentioned is simply an enlargement of one of the terminal bristles of the foot, and serves to fasten the animal to the shell of the female. In one American species of *Pleuroxus* we find an approach to this structure in the female—an interesting example of inheritance of sexual peculiarities across the sexes. The alterations in the form of the post-abdomen consist in a narrowing or excavation of that organ to permit its introduction into the brood-cavity, and in some forms (*Chydorus*) this change can only be understood by observing the form of the shell of the female about to produce winter eggs. In general, as in other *Cladocera*, males are found only at the period when the females are sexually perfect. The ordinary method of reproduction is by virgin-bearing or parthenogenesis. In some cases it would seem, from Weismann's observations, that the sexual method occurs only incidentally. The orifice of the male organs is between, or anterior to, the terminal claws of the post-abdomen (*Eurycercus* alone excepted). The males are usually but not always smaller. Plate LXI gives views of typical *Lynceidæ*. Fig. 1 is particularly instructive, for in it the details which can be usually made out in the living object are represented. The following points may be especially noticed. The large size of the pigment fleck, the large antennules (A^1), the keel of the labrum (Lb.), the peculiar modification of the first pair of feet to assist the maxillæ (not shown) which are exceedingly small, the largely developed anal gland (A. g.), the form and muscular mechanism of the abdomen, which, however, is better illustrated by Fig. 10 of the same plate. Fig. 1 contains an embryo seen from the side with the partially developed limb. Fig. 3 shows the appearance of a different embryo from below and in an earlier stage. Fig. 2 illustrates the relation of the brain to the eye and the very small optic ganglion. Fig. 9 of Plate LXIII gives details of the feet in another species, and the modifications seen in the male of the same species are sufficiently shown in Fig. 1 of the same plate, which also well illustrates the various sculpture of the shell displayed by this group. Figs. 4 and 9 of Plate LXIV show curious modifications of the post-abdomen of the male, and Fig. 7 exhibits the structural peculiarity of sexually perfect females which is correlated with it, or, perhaps, we may say, occasions it.

SUB-FAMILY EURYCERCINÆ.

A single species constitutes the sub-family, and it will be necessary to point out only those points which are distinctive.

The *Eurycercinæ* differ from the true *Lynceidæ* and approach the *Lyncodaphnidæ* in having the digestive tract not coiled, with two cæca

in front and the anus at the end of the post-abdomen. Many eggs are produced at once. The male opening is at the base of the abdomen, as in *Sididæ*. The general habitus is, however, lynceid. The males appear in autumn or when, by the gradual drying up of the water or other causes, the continued existence of the animals is threatened.

GENUS EURYCERCUS Baird.

Characters of the sub-family.

Eurycercus lamellatus O. F. Müller.

PLATES XLVI, FIGS. 7, 8; LI, FIG. 6; LX, FIGS. 5, 6; LXII, FIG. 19.

Lynceus lamellatus—Mueller, Edwards, Koch, Zaddach, Lievin, Leydig, Zenker.
Eurycercus laticaudatus—Fischer, Schoedler.

A gigantic *Lynceid*, reaching the dimension of 3.0 mm. The figure of the male given will sufficiently illustrate the general form. The abdomen is broad and armed behind with a dense row of saw teeth. The eye is larger than the rather small pigment fleck, and the intestine is bent upon itself but not coiled. The last foot is found in few other *Lynceidæ*. *Acroperus* has the same, and *Pleuroxus unidens* also has a rudimentary sixth foot.

SUB-FAMILY LYNCEINÆ.

Intestine coiled; anus near the end of the post-abdomen; opening of vas deferens nearly terminal. There are no anterior cæca but usually a single anal diverticle of the intestine. Rarely or never more than two embryos produced at once.

KEY TO THE SUB-FAMILY LYNCEINÆ.

I. Head or dorsal line keeled or ridged; abdomen long; shell marked with diagonal striæ.
Camptocercus, 227, 228; **Acroperus,** 227; **Alonopsis,** 231

II. Usually no keel above, or, if keeled, the post abdomen is not long. The majority are highly arched dorsally, and have comparatively short post-abdomen and pointed beak. The antennæ are usually feeble and the motion slow.

A. Post-abdomen nearly round in outline, armed with very long, stout spines, terminal claw with one minute basal spine or none; greatest height of shell about equal to the posterior margin. . **Leydigia,** 233

B. Post-abdomen more or less triangular, armed with bristles; greatest height of shell moderately exceeding that of the posterior margin; shell marked with hexagonal meshes.

a. Head nearly horizontal, blunt; post-abdomen prominent in the anal region. . . . . **Graptoleberis,** 235

b. Head depressed, acute; post-abdomen excised near the anus, . . **Dunhevidia** (=**Crepidocercus**), 236

C. Post-abdomen more or less quadrangular, armed with one or two rows of small teeth on either side behind; terminal claws with one or two basal spines; height of posterior shell margin usually less than the greatest height of the shell. . . . . **Lynceus,** 237

D. Post-abdomen terete; greatest height of shell little less than that of posterior shell margin; terminal claws very minute. . **Phrixura.**

E. Greatest height of shell more than double that of the posterior margin.

a. Eye and first foot normal. . . . . **Chydorus,** 260

b. First foot with a claw which extends beyond shell. **Anchistropus,** 264

c. Eye absent, only the pigment spot used for vision. . **Monospilus,** 264

(Not noticed in the key. . **Alona,** 238; **Alonella,** 249; **Pleuroxus,** 253)

SERIES A.—This section is proposed for the old genera *Camptocercus, Acroperus,* and *Alonopsis,* which seem to form a natural group though passing into *Alona.*

GENUS CAMPTOCERCUS (> *Camptocercus* Baird).

This easily recognizable genus contains two groups, each with several nominal species, which are distinguished mainly by the width of the post-abdomen. In both the shell is elongated, more or less quadrangular, longitudinally striate, armed behind with one to four minute teeth. The head and back are keeled and the former strongly arched. The antennules rarely extend beyond the beak and are commonly curved laterally. The eye is proportionately small. The post-abdomen is long and furnished with a lateral row of scales. The terminal claws have a single basal spine and are serrate. There is an ephippium, and the male opening is in front of the terminal claws.

SUB-GENUS ACROPERUS Baird.

Post-abdomen broad, margins parallel; anal teeth very minute, lateral scales large and usurping their place. Antennæ with eight setæ ($\frac{3\,0\,0}{3\,1\,1}$). Three species are described, one of which is very abundant in Minnesota.

*Acroperus leucocephalus Koch.

PLATES LXI, FIG. 5; LXII, FIG. 9.

Lynceus leucocephalus—Koch, Fischer.

Acroperus harpæ—Baird.

Acroperus sp.—Herrick.

Acroperus striatus—Jurine, M. Edwards, Lievin, Lilljeborg, Leydig, etc., seems to belong here, but I am able to add nothing to the elucidation of the puzzle.

Body rounded above, angled behind; head moderately arched and carinated. Lower margin of the shell pectinate, terminating in two

teeth. The antennæ are long and when reflexed the setæ reach nearly to the posterior margin of the shell. The posterior angle is not always as prominent as shown in Fig. 5, Plate LXI.

*Acroperus angustatus Sars.

PLATE LXII, FIG. 10.

This species is distinguished from the former by the head, which is higher and very strongly arched. The dorsal contour is nearly straight. The antennæ are shorter. The form of the post-abdomen of the male is less different from that of the female than in the above. The length of both species is about 0.7 mm.

The American form figured in Fig. 5 of Plate LXI differs from both the above slightly. The head is carinated and incurved almost as in *C. angustatus;* the antennæ fall a little short of reaching the posterior margin of the too low and oblong shell; there is an obvious depression between the head and the body. However, in the main there is close agreement with *C. leucocephalus*, to which it has been previously referred. There is always a rudiment of an additional pair of feet.

A. cavirostris P. E. Mueller, is not known in the female sex. The male has a twisted caudal claw. It is probably founded on an abnormal individual.

Acroperus alonoides Hudendorff.

This species is only known to me from incidental references in Matile. The post-abdomen is said to be broader than in either of the above. The claws have only one basal spine. The crest is low and the macula is nearer the end of the beak than the eye.

(Acroperus transylvanicus Daday.)

"Carina capitis rotundata; testa corporis dorsali leniter rotundato; postice angulo indistincto; margine ventrali fere recto angulum inermem formanti, cauda apice rotundata incisa; unguibus caudalibus magnis, fere rectis. Longit 0.85 to 0.9 mm."

The figures do not greatly fill out this hopeless description. The form is short and so is the abdomen, but the armature of the latter has nothing distinctive.

SUB-GENUS CAMPTOCERCUS Baird.

Although the general form is similar to the last section, the body is usually longer; the post-abdomen narrows toward the end; the anal teeth exceed the lateral row; the antennæ have usually but seven setæ ($\frac{3}{3}\frac{0}{1}\frac{0}{0}$).

The species enumerated are so closely related as almost to baffle definition.

KEY TO THE SUB-GENUS CAMPTOCERCUS (VERUS).

I. Beak pointed.
  A. Head depressed.
    a. Pigment spot larger than the eye. . . . . **biserratus,** 229
    b. Pigment spot smaller than the eye. . . . . **macrurus,** 229
  B. Head directed forward. . . . . **rectirostris,** 230
II. Beak truncate below. . . . . **latirostris,** 230
III. Beak cleft below or with a forward projection.
  A. Antennules shorter than the beak. . . . . **lilljeborgii,** 230
  B. Antennules longer than the beak. . . . . **rotundus,** 230

Camptocercus biserratus Schoedler.

PLATE LXII, FIG. 4.

Is very nearly related to the next, from which it is distinguished chiefly by the fact that the pigment fleck is larger than the eye. Schoedler overlooked the fact that in *C. macrurus* there is a lateral line of scales on the abdomen, and relied upon that character to distinguish this form. (Schoedler says that the pigment fleck in *C. macrurus* is smaller than the eye, P. E. Mueller says they are nearly equal, while in our specimens they are much smaller or nearly equal.) If much variability is found, Schoedler's species seems to rest on a slender basis. The basal spine of the claw, however, seems to be peculiar in sitting on a distinct prominence.

*Camptocercus macrurus Mueller.

PLATE LXI, FIGS. 10, 10*a*.

Lynceus macrurus—Lilljeborg, Schoedler, P. E. Mueller, Kurz, Birge, Herrick.

This universally distributed species occurs in our larger bodies of water and is not rare, though hardly abundant.

The body is long and nearly rectangular; the head strongly arched and keeled. The keel of the head is extended down the whole dorsal line. The dorsal line is moderately curved, while the shell is but slightly excavated below. The head extends into a blunt beak looking downward; the direction of the head is somewhat variable (from vertical to an angle of about 30 degrees). The eye is much larger than the pigment fleck; the antennules are shorter than the beak, and have one elongated terminal seta. The post abdomen is very long and has numerous anal teeth as well as a lateral row of scales. The basal spine of the claws is large and serrate, the claw itself being nearly straight and armed with an increasing series of spines to beyond the middle. The lateral scales of the post-abdomen are inconspicuous. The shell gland is long. The antennules reach to almost

the end of the beak, are curved and bear a lateral flagellum. The first foot of the female has a sort of hook (branchial sac?). The labrum is armed with teeth on the posterior face of the triangular process. The intestine is very strongly, almost twice, coiled. The lower margins of the valves are feebly spined for three-fourths their length, and armed with from one to four teeth at the angle. Length 0.8 mm. to 1.0 mm.

Camptocercus rectirostris Schoedler.

PLATE LXII, FIGS. 1-3.

Distinguished from the above, which it closely resembles, by the form of the head, which is less rounded and directed anteriorly. It hardly exceeds half the height of the body. The beak is sharp. I am not sure that Weismann's figures (l. c., Plate XI, Figs. 13 and 14) really belong to this species, for the drawing of the post-abdomen does not agree with that of P. E. Mueller fully. Outline copies of the former are given in Plate LXII, Figs. 1 and 2. The male has a hook upon the first foot. Not yet recognized in America.

Camptocercus latirostris Kurz.

PLATE LXII, FIGS. 5-6.

C. lilljeborgii, P. E. Mueller (?).

Closely allied to the next, but distinguished by the position of the head, which is a little less depressed, and, especially, by the truncate beak. The dorsal margin is convex and crested; the lower outline is also convex. The claws are toothed more as in *C. macrurus* than the following. The basal spine springs from the claw itself and not from the post-abdomen as in the next. Length 0.9 mm. to 1.0 mm.

Camptocercus lilljeborgii Schoedler.

PLATE LXII, FIGS. 7-8.

Head depressed, rounded in front; beak divided at the end by the extension of the fornices. The terminal claws are pectinate for their entire length, and the basal spine is seated on the end of the post-abdomen. This species, in the main, closely resembles *C. macrurus*.

* **Camptocercus rotundus** Herrick.

The second of the two species found in America is this short, strongly carinated form, which is known from a single gathering. It differs from all the above species, with which it agrees pretty well in shape, by its more compact form; high dorsal keel (which extends the entire length of the body); the long antennules, which extend far below the beak; and the somewhat pointed beak. The head is much as in

the last, but it is not certain that the beak is cleft, although it has a peculiar form (not indicated in the figure) near the end. The length is 0.7 mm. The terminal setæ of the antennules are very unequal; but in most points, as in the armature of the post-abdomen, the details resemble *C. macrurus*. [This is probably but a variety.]

GENUS ALONOPSIS Sars.

This curious genus includes three species of small *Lynceids* which exhibit a combination of characters. The form of the beak and head is like that of *Pleuroxus*, which the form and sculpture of the shell otherwise resembles. The back is extended more or less in a knife-like ridge above, thus resembling *Acroperus*, a resemblance heightened by the excavated lower margin. The form of the post-abdomen approaches that of *Acroperus*, but in that genus it is of about equal width throughout and in this it rapidly narrows. The internal organs and feet are of the typical lynceid form, while the antennæ are as in *Pleuroxus*.

The type of the genus, *A. elongata*, is apparently much closer to *Acroperus* than the two species which have been identified in America.

Shell sub rectangular, high, produced into a ridge above; lower margin convex anteriorly, concave behind; beak rather long; antennules slender; antennæ with eight setæ; abdomen long, narrowed toward end, incised at the extremity; claw rather large, with median spines and a basal thorn; third foot with a long bristle. Male smaller, without the carina above; orifice of sexual organs in front of the claw, which is removed from the anterior margin. The young are more elongate and (sometimes) have hexagonal reticulations instead of the usual strong diagonal striæ. Motion slow.

Alonopsis elongata Sars.

Lynceus macrurus—Lievin, Zenker, Leydig.
Alono elongata—Sars.
Acroperus intermedius—Schoedler.

The shell is wide, the upper margin forming an even curve, manifestly angled behind; ventral margin nearly straight, ciliated throughout, with a single tooth behind. Fornices large; head narrow, not carinate. Post-abdomen compressed, truncate at the end, armed with a series of marginal spines and of lateral scales; caudal claws large, with a single spine at the base and two median spines followed by a series of minute setæ.

This form I have never seen, and it seems somewhat doubtful that the following really belongs with it.

*Alonopsis latissima Kurz.

PLATES LXI, FIG. 8; LXIII, FIGS. 1 and 9.

Body very high, compressed, with a high dorsal keel or ridge; the upper outline strongly and evenly arched, terminating behind in no angle; lower margin almost angled at the anterior third, rounded behind, fringed with long bristles anteriorly, with short ones posteriorly. Head very narrow; beak extremely long; fornices small; antennules nearly as long as the beak, straight and narrow; pigment fleck smaller than the eye. The abdomen is long, somewhat narrowed toward the end, where it is deeply cleft; the terminal claw is furnished with a large and small basal spine, while there is an increasing series of spines extending to the middle.

The elongated spine of the third foot is pectinate and reaches nearly to the posterior margin of the shell. The shell is marked by a few strong striæ which are diagonal except anteriorly where are a few parallel to the front margin. The male is small and lacks the crest on the back, while the lower margin is straight; the antennæ are longer than the beak and differ somewhat from those of the female. The first foot has a claw. The post-abdomen lacks the anal teeth. Kurz gives the size as 0.5 mm.

The American form varies between 0.45 mm. and 0.55 mm., and seems to have a higher dorsal keel and longer beak. Kurz speaks of but a single accessory spine on the terminal claws; there is, however, a second very minute spine or cluster of hairs in this as well as the following.

Found in the same gathering with the following near Minneapolis (marshy off-set from Bassett's creek near Oak Lake Addition):*

*Alonopsis latissima var. media Birge.

PLATE LXI, FIG. 9.

I give Birge's description verbatim.

"Rostrum prolonged, and shell sharp, somewhat quadrangular in shape, marked by striæ. The dorsal margin is convex, the hinder margin nearly straight. Its lower angle is rounded and without teeth. The lower margin is concave and has long plumose setæ. The front margin is strongly convex. The post-abdomen is long and slender, resembling that of *Capnlocercus*, and is notched at the distal extremity; it has two rows of fine teeth and some fine scales above them. The terminal claws are long, slender, with a basal spine, a spine in

NOTE TO ALONOPSIS LATISSIMA. (See Fig. 1, Plate LXIII.) Since writing the above the males of our American form have been found; they are shaped as the females, with a high dorsal keel; the post-abdomen is rounded, with transverse series of small bristles; the claw has a minute median spine, and the porus genitalis is anterior and elevated.

the middle, and are serrated. The antennules are long and slender, but do not reach to the end of the rostrum. They have each a flagellum and sense hairs. The antennæ are small and have eight ($\frac{3}{3}\frac{0}{1}\frac{0}{1}$) setæ and two ($\frac{1}{1}\frac{0}{0}\frac{0}{0}$) spines. The labrum resembles that of *A. leucocephalus*, but is slightly prolonged at the apex. The intestine, cæcum and color resemble those of *Acroperus*. There is a trace of a keel present on the back."

The specimens seen in Minnesota resemble this species very nearly, apparently, but there are some differences. The terminal claw of the post-abdomen has an increasing series of spines to the middle; there seems to be no lateral row of scales beside the anal teeth; the abdomen is rather broad at the base and narrows toward the end. The shell is not square behind. The lower margin has a few long hairs anteriorly which are followed by a series of teeth, and in the concave part a somewhat longer set to a point just before the lower curved angle.

The pigment fleck is nearly or quite as large as the eye. The antennule is shorter than the beak (which is almost as in *Pleuroxus hastatus*), and has a flagellum about midway; at its base it is narrowed and inserted on a prominence.

The embryo still in the brood-sac has a more elongate form and hexagonal reticulations upon the shell, while the antennules were longer than the very long beak, and the pigment fleck was smaller than the eye. Length of female 0.52 mm. The color is darker, and the striæ more numerous, than in *A. latissima*.

From a private letter we learn that this form is now regarded as simply a variety.

SERIES B.—This section includes *Leydigia*, *Graptoleberis*, *Dunhevidia* (*Crepidocercus*), *Lynceus*, *Alona*, *Alonella*, *Pleuroxus*, *Phrixura*, *Chydorus*, *Anchistropus*, *Monospilus*.

GENUS LEYDIGIA Kurz.

In this genus, both the known species of which are found in America, the posterior part of the shell and body is emphasized at the expense of the anterior. The curved posterior margin is equal to the greatest height of the shell. The head and anterior part of the body are of the form characteristic of *Alona;* indeed, the whole body is in plan like *Alona*, but in the back part the organs are all enlarged. The general form of the body and abdomen recalls *Ilyocryptus;* the post abdomen, in particular, is very like that genus. The last two pairs of feet are much enlarged. The shell is usually irregularly marked with longitudinal striæ; the lower margin is covered with long spine-like setæ. The post-abdomen is armed with several sets of

long spines and aggregations of bristles and small spines; it is almost round and enormously enlarged. The intestine is coiled and expanded at the end but the anal cæcum is rudimentary. The antennæ are heavily spined and have eight setæ; the labrum is more or less hairy. The male has a strong hook on the first foot, and between the terminal claws of the abdomen is a peculiar intromittent organ.

* Leydigia quadrangularis Leydig.

PLATES LIX, FIG. 6; LX, FIG. 4.

Lynceus quadrangularis—Leydig, Fric.
Alona leydigii—Schoedler, P. E. Mueller.

The shell is comparable to that of *Alona quadrangularis*, but higher behind; the markings are not very distinct; shell transparent. The head is very small; the eye smaller than or of about the size of the pigment fleck. The post-abdomen is very broad, the posterior margin nearly the segment of a circle, armed with numerous very long unequal spines which extend only about half the height, being replaced by short close hairs; the anal opening is very high; the terminal claws are long, straightish, and have a small thorn near the base.

The males are smaller than the females, and the abdomen is less broad; the antennules are longer than the beak and furnished with a flagellum. The sexual period occurs in September or irregularly. This species has only been encountered once, during September, in Poplar river, Cullman county, Alabama.

* Leydigia acanthocercoides Fischer.

Lynceus acanthocercoides—Fischer, Leydig.
Eurycercus acanthocercoides—Schoedler.
Alona acanthocercoides—P. E. Mueller.
Leydigia quadrangularis—Herrick.

This species, reported in a previous paper, is, as was said, nearest like *L. acanthocercoides;* and I am now able to verify the very inconspicuous differences upon which the two are separated. Our specimens of the *L. quadrangularis* have the pigment fleck fully as large as the eye, Kurz to the contrary notwithstanding, and the spine of the claw of the post-abdomen is present, while in the present species the pigment fleck is much larger and furnished with lenses; the spine of the claw is wanting; the labrum is densely hairy; the abdomen is narrower, and the shell higher. The shell is very obviously striped in the posterior portion. The anus is higher than in the previous species. In ther respects the two seem alike.

[**Alona balatonica** Daday.]

This is apparently simply *L. acanthocercoides* with unusually sharply marked shell. The figures are very poor.

Leydigia australis Sars.

PLATE LXVI, Fig. 7.

Very similar to *L. acanthocercoides*. Head comparatively erect, rostral projection not much curved. Body quadrangular, expanded behind and obliquely truncate. Macula nigra at least three times as large as the eye. Antennules reaching nearly to the end of the beak. Abdomen very large, lamellar. Spines about 20, increasing distad. Length 0.84 mm.

The points most relied on to distinguish the species are the large size of the macula and the absence of teeth from the claws. A very full description with numerous figures is given by Sars.

GENUS GRAPTOLEBERIS Sars.

A genus having affinities with *Alonella*. The shell is entirely reticulated, and there is a sort of crest along the back; while, on the other hand, the head is flattened and rounded in front. There can hardly be said to be a beak. Seen from above, the animal resembles some species of *Alonella*, but the head is larger proportionally and more horizontal. The lower posterior angle is spined. The antennæ have seven setæ and are very long, in this respect resembling *Camptocercus*. The dorsal contour is not greatly arched. The post-abdomen has short claws and anal bristles, but no teeth.

* **Graptoleberis testudinaria** Fischer.

PLATE LXV, FIGS. 8, 11, 12.

Lyncens testudinarius—Leydig, Lilljeborg.
Lyncens reticulatus—Fric.
Alona testudinaria—Schoedler.
Graptoleberis inermis—Birge.

Form trapezoidal; lower margin straight, armed behind with two teeth, thickly beset with long hairs in front; the dorsal margin is not greatly elevated, rounded at the posterior angle, forming a slight "hump" where it unites with the head shield. The head and shell are reticulated with hexagonal or quadrangular markings. The shell gapes below and rises to a sharp ridge above. The antennæ have long rami, the antennules being hardly longer than the fornices. The eye is large; the pigment fleck is small. The post-abdomen is narrowed

toward the end, rounded in front; the terminal claws are small and have two basal teeth. The dorsal margin of the post-abdomen is covered with tufts of hairs. The winter eggs have no ephippium. Length 0.55 mm. to 0.7 mm. The male is smaller and has a lower dorsal keel; the post-abdomen is excavated behind.

The only differences between the Minnesota specimens and the typical European form seemed to be the absence of the very minute spines on the front of the terminal claws. The eye and pigment fleck are of about the proportions figured by Kurz. Birge's figure of the post-abdomen does not agree with his description fully. Our Minnesota specimens have an obvious but not high keel.

* **Graptoleberis reticulata** Baird.

Alona reticulata—Baird, P. E. Mueller.
Lynceus reticulatus—Lilljeborg, Leydig.
Alona esocirostris—Schoedler.

Shell almost rectangular, reticulate, ventral margin straight, ciliate anteriorly, with two teeth behind. Pigment fleck smaller than the eye. Post-abdomen short, narrowed towards the end, dorsally covered with clusters of spines; caudal claws with a minute tooth at the base. Length 0.4 mm. to 0.5 mm.

The pigment fleck is nearer the end of the beak than the eye, and is smaller than in the previous species, but, on the whole, there is, perhaps, too great similarity.

Professor Birge writes that he unites the two species.

GENUS DUNHEVEDIA King.

Crepidocercus—Birge.

The characters of this group place it rather near *Alonella* or between that and *Pleuroxus*. Form sub-quadrate with rounded angles; dorsal line uniformly arched, terminating in a sharp angle behind; lower margin convex, armed behind with a single spine as in *Pleuroxus unidens*, and along the entire length with loose setæ. Beak of moderate length, acute. Post-abdomen deeply incised in the anal region; lower posterior margin straight, rounded at the apex; ventral margin straight or concave; claws with a single basal spine and a few teeth. The post-abdomen is shoe shaped and armed with transverse rows of setæ.

The antennæ are large, having eight setæ and the usual spines. Shell smooth or reticulate. Founded by King to include two species from Australia, *D. crassa* and *D. sodagra*.

***Dunhevedia setiger** Birge.

PLATE LXIV, FIG. 3

Length 0.4 mm. to 0.5 mm. Minnesota specimens measured 0.5 mm. This species is but rarely encountered, and is so peculiar as to be easily recognized when seen. *Alona intermedia* has a post-abdomen with clusters of bristles, but in *Dunhevidia* the post-abdomen is more as in species of *Graptoleberis* than any other genus. The markings upon the shell are very indistinct. Birge says that the male is similar in form to the female. The first foot has a stout hook. The claws are smooth in both sexes. This species has been found by Daday in Hungary.

GENUS LYNCEUS O. F. Müller.

The perplexing inter-relations between the three genera *Alona*, *Alonella* and *Pleuroxus* give rise to the utmost confusion. No two authors are agreed as to their respective limits, and the points given by Kurz, who has carefully gone over the ground, are obviously insufficient. Although there may be practical benefits to be derived from the continuance of the nomenclature in use for groups which in the general view can be distinguished, the value from a theoretical standpoint is reduced to a minimum.

The genus *Camptocercus* (including here *Acroperus*, which differs solely in the form of the abdomen, as a sub-genus) passes through *Alonopsis* into the group represented by *Alona*. *Leydigia*, although very near such forms as *Alona quadrangularis*, may be conveniently distinguished as a transition to species like *Ilyocryptus*.

Phrixura, *Graptoleberis* and *Dunhevidia*, each containing few species which can be readily recognized, fill a place in the system; but it is practically impossible to distinguish *Alona* from *Pleuroxus* without instituting the very indefinite genus *Alonella* to contain a variety of small intermediate forms. *Percantha*, *Rhypophilus*, *Harporhynchus* and *Pleuroxus* seem to be pretty generally regarded as constituting a single group which may be recognized by the long rostrum, high shell and greater development of the antenna bristles. *Alona*, on the other hand, with its broader fornices, shorter beak, fairly developed antennæ, and more rectangular shell, is, perhaps, the pivotal point of the group. According to this view, then, the old name *Lynceus* is revived for the aggregate; and the other names are retained, in part, as titles of largely conventional groups or sub genera, thus:

GENUS LYNCEUS.

Sub-Genus Alona—Section A, *Alona vera.* Section B, *Alonella.*
Sub Genus Pleuroxus—Section A, *Pleuroxus verus.* Section B, *Leptorhynchus.*[1]

Characters of *Percantha* and *Rhypophilus* are combined in the species *P. procurvus*, Birge, so that one must be dropped or new diagnoses formulated. I am not sure that the same species is not at first *Pleuroxus verus*[2] and only later assumes the form known as *Rhypophilus.* So with *Percantha* the amount of serrature of the posterior margin is in part a question of age.

SUB-GENUS ALONA.

This group contains two sections which resemble each other in form and, in general, in detail; but it is exceedingly difficult to formulate a diagnosis that shall strictly limit it. The form is generally subquadrangular with rounded corners; the terminal claw is armed with but a single spine at the base; the beak is rather short; and the prevailing marking consists of longitudinal lines.

Section A, **Alona (vera)** Baird.

This genus contains a large number of minute animals which are widely distributed.

The authors who have done the most to elucidate this genus are Schoedler, P. E. Mueller and Kurz. Birge has contributed most largely, thus far, to the knowledge of American species, which are, for the most part, identical or very close to the European. No other genus is so difficult among the *Lynceidæ*, for the most minute differences are relied upon to distinguish species. The species of this genus are not greatly altered by the production of the winter eggs. The males are frequently but little smaller than the opposite sex, and are recognized by the altered form of the post-abdomen and the presence of a hook on the first foot. The form is more perfectly rectangular than in the next section; the shell is only exceptionally reticulated and very rarely tuberculate, occasionally smooth. The lower angle of the shell is not armed with spines, but is generally rounded. There is only one basal spine upon the claw of the post-abdomen, which usually bears a row of scales beside the anal spines. The antennæ have eight setæ. The claw of the male post-abdomen is removed from the lower angle.

Many species are known, all of which that seemed recognizably defined have been included in the following key, which is believed to

1 Instead of Harporhynchus, a name preoccupied in zoology.
2 Embryos of P. procurvus have the part which is to be curved forward attenuated before leaving the brood cavity, however.

more nearly represent our present knowledge of the genus than that of the previous edition. Unfortunately the key must be based on the statements of other authors, and in this genus it is rare to find complete agreement between the published descriptions. The best thing a student can do is to disregard much of the synonomy and make an exhaustive study of a species from a large number of individuals in one locality and then cautiously extend the range of work to include adjacent stations.

KEY TO THE GENUS ALONA.

I. Macula cerebri much larger than the eye. . **sanguinea,** 239; **moniezi,** 240

II. Macula cerebri about as large as the eye. **quadrangularis,** 240; (**affinis,** 240 **oblonga,** 240;) **lepida,** 242. . . . . (See also **intermedia,** 244)

III. Macula cerebri smaller than the eye.

A. Post-abdomen narrowed toward the end, at least not broadly rounded.

a. A single series of anal spines.

* Striæ oblique to the axis of the shell. . . . . **lacustris,** 242

** Striæ parallel to the axis of the shell.

† Abdomen very long, with long anal spines. (One form of) **tenuicaudis,** 242

†† Abdomen not very long. . . . . **guttata,** 243

b. A lateral as well as an anal series of post-abdominal spines, setæ or scales.

* Post-abdomen long and slender. (Usual form of) **tenuicaudis,** 242

** Post-abdomen of ordinary form.

† Anal spines two. Row of setæ in addition. . **dentata,** 244

†† Anal spines represented by transverse clusters of bristles. **intermedia,** 244

††† Anal spines large, nearly equal. . . . . **pulchra,** 245

†††† Lower anal spines larger. . . . . **porrecta,** 246

B. Post-abdomen broadly rounded below.

a. Anal spines in a single series. . . . . **stagnalis,** 246

b. A double series of anal spines.

* Striæ of shell close, fine and oblique. . . . . **elegans,** 247

** Striæ of shell distant.

† Striæ oblique. . . . . **angulata,** 247

††Striæ parallel to the longitudinal axis of the shell. **coronata,** 247

(Not noticed in the key. . . . . **costata,** 245; **barroisi,** 248)

***Alona sanguinea** P. E. Mueller.

PLATE LXII, FIG. 20.

Body nearly rectangular; ventral margin nearly straight, with short setæ; posterior angle rounded, unarmed. Beak short; pigment fleck much larger than the eye. Post-abdomen large, the end truncate, broadened; posterior margin rounded, with a series of spines and a

lateral row of scales; terminal claw with a small spine. The shell is ornamented with fine, close, longitudinal striations. Length 0.9 mm. *Alona elegans* is very near to this and should have followed. In August, 1878, I took an *Alona* marked as in *A. sanguinea* and agreeing with Mueller's description in all points which can be verified in the drawing. The small size of the eye is remarkable for so large an animal. I have never again seen this species; it seems to be very rare here and in Europe.

Alona moniezi Richard.

Richard '88.

"Testa antice quam postice latior, striis multis, interdum areis ornata, supine sat arcuata, postice fere truncata, angulo inferiore rotundato, inferne subrecta, ciliis longis, hic obsita. Antennæ 1mi paris apicem rostri fere attingentes. Articulus ultimus utriusque rami antennarum 2 di paris, setis 5 longis et aculeo forti præditus. Rami exterioris articulus penultimus longa seta instructus. Macula nigra oculo major, inter hunc et apicem rostri in medio sita. Post-abdomen breve latitudine fere æquali, ad angulum posteriorem et inferiorem rotundatum, seriebus (8-9) aculeorum (4-5 quorum exterior multo major) fusiforminm, præterea aculeis minutis æqualibus fasciculatim usque ad processum obtusum positis, armatum. Adest denique series lateralis squamarum spinis gracilibus ac longis compositarum. Ungues terminales sat longi, usque ad apicem ciliis minutissimis obsiti, dente basli gracile, et sat magna. Setæ abdominales longæ. Mas femina majore paulo dierepans. Postabdomen brevius, latum, spinis unguibusque terminalibus multo brevioribus quam infemina, ornatum. Pedes 1 mi paris in hamulo valido curvato ad basin crasso, apicem versus acuto exeuntes. Longit. fem., 0.5-0.55 mm.; mas., 0.45-05 mm."

Found near Vichy.

* **Alona quadrangularis** Müller.

Plate LXI, Figs. 1, 2.

Alona oblonga—P. E. Mueller.
Alona affinis—Leydig.
Alona sulcata—Schoedler, Hudendorff.

The group of forms included under the above names is in inextricable confusion. Hellich evidently describes the same species as *quadrangularis* and *affinis*. *Affinis* falls little short of one millimeter in length while *quadrangularis* is less than 0.75 mm. *A. oblonga* is said by Kurz to measure 0.8 to 0.9 mm. He, however, did not know *A. affinis*. Hellich says that there is a secondary marking of the shell in *A. affinis*. The claws are smooth in *quadrangularis* and ciliate or toothed in *affinis*. Statements of various authors differ respecting the relative size of eye and pigment fleck.

The American form, which most closely approaches *affinis*, has the claws denticulate and the pigment fleck smaller than the eye. In the figure (Plate LXIV, Fig. 14) the head is somewhat protruded by

pressure, but there is nevertheless greater proportional length than in ordinary specimens of *A. quadrangularis*, and we may have to do with a new species.

Accordingly we quote our original description.

"Form sub-quadrangular; height about once and one-half in length; the dorsal outline forming a regular and low curve from end of head to upper posterior margin; lower outline very slightly sinuate, anterior one not at all; posterior angles rounded; head nearly horizontal; eye of moderate size; pigment fleck considerably smaller; antennules rather large, with unequal sensory hairs at the end, one spine just above the end in front and a bunch of minute hairs near the base behind; antennæ comparatively large, basal joint spiny, outer ramus with three setæ, two of which have thorns at their middle, also a terminal spine; inner branch with two of the terminal setæ thorned and the upper lateral setæ reduced. The post-abdomen is very broad and short, expanded below and rounded at the end; the terminal claws are straightish, denticulate, and the spine at the base is also dentate; there is a series of heavy spines on the upper margin of the post-abdomen, accompanied by a series of scales on the side. The shell is unornamented and fringed below with short bristles. Length 0.9 mm., or more. This fine species is recognized by its smooth shell, the horizontal position of the head, and the form of the post-abdomen; it belongs among the largest of the genus. Lakes near Minneapolis not rare.

"Birge quotes *A. spinifera* from Wisconsin. In all probability that species is the younger stage of the above."

The American form, which we identified with *Alona oblonga*, was said to differ from *A. quadrangularis* in the following points:

"The greatest height of the shell is anterior to the middle; the lines are less evident, and all confined to the lower part of the shell, while the centre of the valves is marked with very minute striæ; the pigment fleck equals the eye, and the post-abdomen is of about the same width throughout and hardly as round below. This and the preceding species have a well-marked keel on the process of the labrum. The size is greater, this being one of the largest and most abundant, as well as one of the most striking species. It, perhaps, should rank as a well-marked and permanent variety of the above. Length 0.9 to 1.0 mm. The abdomen of the male is narrowed at the end and lacks the teeth. Lakes about Minneapolis.

"(A small form of *A. quadrangularis* in Lake Calhoun had the eye and pigment fleck equal and the terminal claw smooth.)"

We are satisfied that a wide range of variation must be allowed for. The presence or absence of markings is unreliable.

* Alona lepida Birge.

General shape of the genus. Head depressed, rostrum sub-acute, nearly reaching the level of the ventral margin of the shell. Valves quadrangular, dorsal margin arched, caudo-dorsal angle obtuse, well marked. Caudal margin oblique, bearing a row of spinules. Caudo-ventral angle rounded, very slightly emarginate. Ventral margin with plumose setæ. Valves marked by closely-set, conspicuous, longitudinal striæ, alternately stronger and weaker, occasionally anastomosing, parallel to the dorsal and ventral margins and converging to a reticulated area at the cephalo-ventral portion of the valves. The antennules extend nearly to the end of the beak, are small, spindle-shaped. Antennary setæ $\frac{300}{311}$. The terminal setæ are of unequal length. All are plumose and without spines. The eighth seta is of moderate length, bi-articulate and plumose. Spines of antennæ $\frac{101}{100}$. Eye moderate. Macula about as large as eye, angular, and somewhat nearer to eye than to apex of rostrum. Post-abdomen enlarged posteriorly, lower angle rounded, bearing 15 to 17 serrate post-anal denticles and about the same number of squamæ. Terminal claws smooth. Basal spine rather large. Abdominal setæ of ordinary length. Length 0.8 mm.; male 0.6 mm. Obviously this species is near to *A. elegans*.

Alona lacustris Daday.

Daday '88.

"Rostro brevi; macula cerebrali oculo minore; labro processu mediali glabro; testa corporis striis longitudinalis dense vestita, linea dorsali parum arcuata, margine ventrali subrecto, setas postice breviores gerenti, postice angulum obtusum inermem formanti; cauda brevi, apicem versus rotundatum attenuata serie fere marginali aculeorum sensim minorum armata, unguibus caudalibus unidentatis. Longit. fem., 0.4–0.5 mm.; altit. 0.35–0.4 mm."

It is questionable whether this form is sufficiently differentiated from *A. parvula*; it is also very like *A. guttata=A. intermedia*.

Alona tenuicaudis Sars.

Plate LXII, Fig. 11.

Alona camptocercoides—Schoedler.

Form nearly rectangular; ventral margin rounded, with long setæ, posterior angle rounded. Beak short, pigment fleck smaller than the eye. Post-abdomen with sides parallel, long, incised below; lower angle armed with about six strong teeth, remainder of the series small; a lateral line of scales present; claws with a strong basal spine. The shell is striate with longitudinal lines. Length 0.5 mm.

One of the most easily recognized species; not identified in America.

It would appear that the lateral line of scales upon the post-abdomen may be absent. There is often, if not always, a cluster of fine spinules above the spine on the otherwise smooth claw of the post-abdomen.

Alona guttata Sars.

Norman and Brady '67 (Lynceus guttatus); Kurz '74 (parvula and tuberculata); Hellich '77 (anglica, and guttata); Matile '90.

A small species of sub-quadrangular form. The beak is very short; the eye small, but larger than the minute pigment fleck. The shell is short, with a rounded posterior angle and marked by hexagonal or rectangular meshes running about parallel with the lower margin. The post-abdomen is of moderate size, rounded at the apex, with a series of stout teeth behind; the terminal claw has a minute basal spine. P. E. Mueller, in Danmark's Cladocera, confused this with *A. intermedia*, which he described under this. The post-abdomen in that species is larger, less rounded behind, and armed with clusters of spines instead of teeth. The length is about 0.3 mm. in both. In males the hook is small and the anal spines are absent.

*"*Alona parvula* Kurz is said to have the body sub quadrangular, arched above; ventral margin straight, rounded behind. Shell marked by longitudinal, feeble and irregular lines. The post-abdomen is narrower toward the end, with eight or more teeth; the row of scales is absent; at the end it is sharply truncate and incised; the claws have short basal spines. Hardly to be distinguished from the next.

*"*Alona parvula* var. *tuberculata* Kurz (*Alona tuberculata* Kurz) described by Kurz in 1874, and more at length by Lutz under a different name (*Alona verrucosa*) in 1878, appears to be simply a tuberculate variety of the above. Observations upon the American representatives of the two forms indicate a close relationship between them. The shell is covered with rows of tubercles (or depressions?) which vary in number greatly.

"I do not know how to distinguish *Alona glacialis* Birge (Plate LXIII, Figs. 2, 3 and 8) certainly from *A. parvula*. It, however, seems to have the lower angle of the post-abdomen less squarely truncate and the incision less obvious. Birge says that the abdomen is rounded. I have found specimens which apparently belong here, with the post-abdomen rather sharply angled and deeply incised; there were about fourteen teeth with a row of hairs in front. The form is hardly to be distinguished from another variety which has a shorter post-abdomen, rounded below, and with only about seven or eight teeth and with a smooth shell. This form passes directly into a tuberculate variety, having the post-abdomen similar but the shell covered with numerous

rows of tubercles. Sometimes a transition from a lined shell to a tuberculate shell is seen (as in Plate LXIII, Fig. 14). *Alona tuberculata* Kurz is said to have a truncate and incised post-abdomen with no lateral row of hairs. Birge thinks these identical; if so, our form referred to *A. glacialis* is identical with *A. parvula*. There is also a form found with the above in which no markings are visible and the shell is considerably arched; these were, however, nearly all ephippia females or approaching that period.

*"*Alona glacialis* (?) var. *tuberculata* Herrick (Plate LXIII, Figs. 4-7 and 14) will, then, be our tuberculated *alona* with a lateral row of scales and a series of fine spines along the anus. *Alona glacialis* (?) var. *lævis* Herrick is the smooth form with higher dorsal margin.

"The antennæ of the two last have spines at the end of the rami of the antennæ, a circlet of spines on the outside of the second joint of the setose ramus, and a spine on the basal joint of the other ramus; two of the setæ at the end of the setose ramus have spines at the angles. The males found among the above small forms have the same characters as var. *lævis* and the abdomen is rounded at the end; the claw is situated in the middle of the lower margin, in front being the opening of the *porus genitalis* and behind a cluster of hairs; the spines are absent, but there is a lateral row of long bristles. A strong hook is found on the first foot. Length 0.3 mm."

To the above, which expressed my opinion in 1884, I can only add that I am more than ever convinced that all should be united (probably with *A. guttata*).

Alona dentata P. E. Mueller.

PLATE LXII, FIGS. 12, 13.

Form sub-rectangular, somewhat arched above, obscurely longitudinally striated; lower angle obtuse, margined below with short setæ. Post-abdomen small, slender, armed with a lateral line of scales and two strong teeth at the lower angle; claw with a minute basal spine. The form of the post-abdomen is identical with *Harporhynchus falcatus* Sars, which this species also resembles in having the pigment fleck larger than the eye, and in general form and the character of the striation. The beak, however, is very short. In size P. E. Mueller says it is among the smallest of the genus.

Alona intermedia Sars.

PLATE LXII, FIG. 15.

Alona guttata—P. E. Mueller.

Form sub-rectangular, rounded below; beak short; shell marked by longitudinal lines, which may be broken into indistinct rectangular

meshes. Post-abdomen short and wide, rounded at the end, ornamented by seven or eight clusters of minute spines behind as well as a lateral row of scales. Length 0.43 mm.

Hellich says the pigment fleck is larger than the eye and is farther from the end of the beak than from the eye.

Alona pulchra Hellich.

Sars '61 (rectangula and lineata); Hellich '74 and '77 (lineata); Matile '90.

We are influenced by Matile in not recognizing *A. lineata* Fischer and substituting Hellich's name. *Alona lineata* of Kurz is said by Matile to be *A. costata* Sars.

Body small, elongate oval, truncate behind and of a pale color. Greatest height near the middle. The upper margin is rounded, the lower one somewhat sinuate, with setæ of moderate length. The beak is short, reaching nearly to the level of the lower margin of the shell; the pigment fleck is one half the size of the eye, to which it is much nearer than to the end of the beak. Post abdomen short, broad and tapering toward the end, truncate, armed with seven to eight large teeth; short caudal claws with a small basal tooth. Shell marked with distinct lines running horizontally. The ephippial females are recognized by a deep color and the greater elevation of the back Length 3.8 to 4.00 mm.

I am unable to satisfactorily differentiate the species of this group.

* **Alona costata** Sars.

PLATE LX, FIG. 3.

Alona lineata—Schoedler, Kurz, P. E. Mueller.
Alona modesta—Herrick.

We need not attempt to unravel the perplexing synonomy. As thus defined the species seems to be common in Europe and America. Shell quadrangular, widest behind the middle. Beak of moderate length. Pigment fleck smaller than the eye and midway between eye and beak. Antennæ with only seven setæ. Labrum small. The shell is strongly and coarsely striped parallel to the shell margins. Lower margin straight or concave, armed with rigid setæ. Cœcum long. Post-abdomen rather short, acute and excavated at the distal end. Anal spines nine or ten, equal, with a secondary series of scales. Claws smooth, except for a basal spine. Length 0.55 to 0.65 mm. The claw of the male lacks the basal spine.

The Minnesota representative of this widely distributed species differs in some respects. The lower margin is nearly straight and

rather sparsely hairy; the beak is blunt, but, on account of the spreading of the extremely wide fornices, does not appear so except under pressure.

The beak reaches nearly to the lower shell margin. The antennules are narrow, one or more of the setæ being elongated. The dorsal margin is either nearly straight or strongly arched behind; in either case the greatest height of the shell is back of the middle. The pigment fleck is large. The post-abdomen is just as in *A. costata*, but the lateral row seems to be of spines rather than fringed scales. The shell is marked by rather evident or indistinct lines. The form agrees pretty well with Schoedler's figure, except that the posterior shell margin is much higher. The antennæ have eight setæ, but the last one is very weak. The terminal setæ seem sometimes to be spined, as figured by Schoedler, but in some specimens they are perfectly smooth. There is a circlet of spines on the second joint of the setose ramus. There is a hair on the inner aspect of the protuberance of the labrum. The eye is somewhat nearer the pigment fleck than is the end of the beak.

There seems to be no occasion for separating the American form (Plate LX, Fig. 3), in which the length varies between 0.41 mm. and 0.55 mm. The smaller forms have the back most rounded, while a specimen 0.55 mm. long will appear very like *A. quadrangularis*. Males are elongate; hook of first foot strong, accompanied by a heavy growth of small spines; terminal claw of abdomen with a minute spine.

*Alona porrecta Birge.

Sub rectangular; ventral line nearly straight; valves marked by longitudinal striæ; beak short. Post-abdomen truncate, with about twelve teeth, three or four of which at the end are larger, and a row of hairs above the teeth. Male similar. Length 0.34 mm. Distinguishable from the following small species in the armature of the post-abdomen.

The lower angle of the post-abdomen is acute. The claws are not serrate, but possess the basal spine. The post-abdomen is said to resemble that of *A. tenuicaudis* in its armature, but not otherwise. This species is not enumerated by Professor Birge in his List of Crustacea Cladocera from Madison, Wisconsin [1891], and we are left in doubt whether the species is abandoned or not.

Alona stagnalis Daday.

"Rostro longisculo, paulum curvato, acuminato; macula cerebrali oculo minore; labro processu mediali glabro; testa corporis longitudinaliter, manifeste striata, linea dorsali rotundata, margine ventrali medio parum arcuato, setas ubique me-

diocres gerenti, postice angulum obtusum, inermem formante; cauda brevi, apicem versus rotundatum dilatata, margine dorsali utrinque serie marginali aculeorum 7-8 sensim minorum et pleuribus minimorum æqualium armata; unguibus caudalibus inermibus dente basali uno. Longit. fem., 0.4–0.48; alt. 0.18–0.22 mm."

While doubting the integrity of this species we are unable to place it and quote the author's description.

Alona elegans Kurz.

PLATE LXII, FIG. 14.

Form rectangular; back slightly elevated, posterior margin high, lower margin straight. Shell covered with minute striations springing from the region of the attachment of the head shield. Head rather large, pigment fleck smaller than the eye. The antennæ have eight setæ and a circlet of spines on the second joint of the inner ramus, and a single thorn on its first joint. The post-abdomen is short and broad, rounded at the end, and is armed with about ten anal teeth and a lateral row of scales. Length 0.4 mm. to 0.5 mm.

*Alona angulata Birge.

Dorsal margin considerably arched, terminating in a more or less obvious angle at the hinder corner; the hinder edge is convex, as is also the front margin; the ventral margin bears plumose setæ. Beak pointed, extending nearly to level of ventral margin of the valves. Fornices broad. Shell obviously striated diagonally and less obviously marked by cross lines. Post-abdomen broad, truncate; about twelve anal teeth, with a series of scales and hairs back of them. The pigment fleck is much smaller than the eye. Male smaller; beak shorter; post-abdomen with a lateral row of hairs; anterior feet hooked; sculpture less distinct. [Birge.] Length of female 0.4 mm.; male 0.35 mm.

Whether Professor Birge still continues this species does not appear, but it is dropped from the list of Madison Cladocera.

Alona coronata Kurz.

Hellich identifies this with his *A. pulchra*, but with Matile we regard this as doubtful. The resemblance to *A. pulchra* [*lineata*] is very close, the outline being identical. The lower margin is sparsely hairy. The beak is blunt. A half circlet of teeth ornaments the end of the middle segment of the inner ramus of the antennæ. The macula is but little smaller than the eye. The post-abdomen is broad as in *A. elegans*, not narrowed at the end, but broadly rounded. The anal

spines are represented by clusters of hairs and there is a secondary series of scales. Kurz lays great stress on the fact that the intestine is flexed rather than coiled. Length 0.35 to 0.42 mm.; male 0.3 mm. Abdomen only armed with a series of delicate hairs.

Alona barroisi Moniez.

We quote the description of *Alona barroisi* Moniez ('88). This form is very incompletely described from a single specimen. It is said to be very small and finely striate.

"Il est extremement petit, beaucoup plus bombe sur le dos qu'aucun autre *Alona* et la bord inferieur de la carapace est fortement arrondi, rappelant ainsi les *Leydigia*. Ce bord est muni de courtes soies; l'ocelle est environ moitie plus petit que l'œil, l'appendice labial est large et arrondi sur les trois cotes libres; le post-abdomen est court, son crochet terminal depourvu d'anguillon a la base, les dents laterales en sont courtes et larges et il y a sur les cotes serie de plaques, la carapace est finement striee."

Island of Terceira, Azores. It is doubtful whether it can be recognized.

I venture to add a few memoranda respecting the long list of names which have appeared within this genus and which for various reasons are not included in the above list. Unfortunately the list is incomplete and can only serve at best as a sort of guide to the perplexities of the synonomy.

A. anglica Hellich is *A. guttata*.
A. acanthocercoides of various authors is *A. Leydigia*.
A. aculeatus is *Alonella exigua*.
A. angusticaudata Hudendorff is *Alonopsis latissima*.
A. balatonica Daday is *A. Leydigia*.
A. camptocercoides Schoedler is *A. tenuicaudis*.
A. exocirostris Schoedler is *Graptoleberis*.
A. excisa is *alonella*.
A. elongatus Sars is *Alonopsis*.
A. falcata Sars is *Leptorhynchus*.
A. grisea is *Alonella*.
A. glacialis Birge is a variety of *A. guttata*.
A. inornata Hudendorff is *A. coronata*.
A. insculpta is *Alonella excisa*.
A. leydigia is *Leydigia*.
A. lineata Fischer is unrecognizable.
A. latissima is *Alonopsis*.
A. minuta Poggenpol is insufficiently described.
A. modesta Herrick is *A. costata*.
A. nanus is *Alonella pygmea*.
A. ovata Baird is uncertain.

A. pygmæa is *Alonella*.
A. parvula Kurz is *A. guttata*.
A. rectangularis is *A. pulchra*.
A. rostrata is *Alonella*.
A. reticulata Bd. is *Graptoleberis*.
A. striata is *Alonella*.
A. sulcata is *A. quadrangularis*.
A. spinifera Schoedler is the young of some species.
A. socors O. F. Müller is uncertain.
A. tuberculata Kurz is *A. guttata*.
A. tuberculata Hudendorff is *A. coronata*.
A. transversa is *Alonella pygmæa*.
A. testudinaria is *Graptoleberis*.
A. verrucosa Lutz is *A. guttata*.

Section B, **Alonella** Sars.

In this group are included small species with a combination of characters, forming the link between *Alona* and *Pleuroxus*. An obvious character is the fact that the shell is usually partly marked by oblique striæ, which run in two directions: first, a set extending forward and upward from the lower posterior angle of the valves; second, a set springing from the anterior and lower angle, running across the others. At the central part where these two series intersect, they each become zigzag; the result is a series of hexagonal markings, which may extend to the middle of the lower margin.

The beak is short and the fornices broad; the shell is more or less rectangular, but somewhat elevated in the middle above.

There are usually but seven setæ on the antennæ, or the eighth is a minute hair; on the ramus having the lateral setæ one of the terminal setæ is frequently reduced. In many cases the whole shell is marked by minute striæ in addition to the proper markings, but this is also found in some species of the true *Pleuroxus*. Kurz gives, as a character of *Alonella*, the presence of but a single basal spine to the claw of the post-abdomen; but P. E. Mueller figures two spines on the claws of one of his species (*A. exigua*), and Schoedler figures eight setæ on the antenna of *A. excisa*. American specimens of *A. excisa* and of *A. pygmæa* both certainly have a very minute eighth seta. There remains, therefore, positively no point which can be relied upon to distinguish these little *Lynceids* from *Pleuroxus* or *Alona*. Perhaps, however, these species, as a group, may be recognized by what has already been said. Three species are found in Minnesota.

KEY TO THE GENUS ALONELLA.

I. Rostrum long, bent backwards. . . . . **rostrata,** 250
II. Rostrum short.
  A. Lower posterior angle toothed.
    a. Shell more or less reticulate.
      * Reticulated areas minutely striate. **pulchella,** 250; **excisa,** 251
      ** Reticulated areas smooth.
        † Head depressed. . . . . **exigua,** 252
        †† Head horizontal. . . . . **grisea,** 252
    b. Shell marked by lines running diagonally upward and backward. . . . . **pygmæa,** 253
  B. Lower posterior angle smooth, shell longitudinally striate. **striata,** 253

Alonella rostrata Koch.

Lynceus rostratus—Koch, Lilljeborg, Schoedler.
Alona rostrata—P. E. Mueller.
Pleuroxus acutirostris—Birge.
Pleuroxus affinis—Herrick.

Body long, rapidly narrowed behind; dorsal line strongly arched in front toward the depressed head: the lower margin straight, with 0–3 small teeth at the angle. The fornices are broad, but the beak is sharp; the pigment fleck is but little smaller than the eye, to which it is three times nearer than to the beak. The post-abdomen is long, very much as in *A. excisa*, but longer. Length 0.4 to 0.5 mm. Schoedler says the lower margin is concave and the angle unarmed, a condition not inconsistent with specific identity, as can be seen in many other species. The shell seems to be variably marked, but most conspicuous are the diagonal, curved striæ. Schoedler compares the sculpture to *P. exiguus;* Kurz, however, leaves the impression that only slight reticulation is present in the female.

The male has the post abdomen narrowed, ornamented with clusters of hairs behind, and the small claws have no basal spine, while the genital opening is in front of the claws.

* Alonella pulchella Herrick.

PLATE XIII, FIGS. 1-3.

A minute form very recently obtained is described under the above name. Although closely allied to *A. exigua*, this species is more like *Graptoleberis* than any other member of the genus. It is the smallest of the *Lynceids*, excepting *A. pygmæa*. The shell is high and rather strongly arched; the posterior margin is short and armed with four teeth below, which point in different directions as in *Graptoleberis*. The head is short and the antennules long. The pigment fleck is of

moderate size, but smaller than the eye. The post abdomen is short, rounded below, and armed with sharp and small anal teeth, besides which is an inconspicuous row of minute setæ. The claw is very small, and has a single very minute tooth. The shell is marked by reticulations, which below are regular hexagons but above pass into elongated meshes, and finally on the beak and head become longitudinal striations. The areas are lined as in *A. excisa*. Thus this species combines the form of abdomen of *A. exigua* with the teeth of *Graptoleberis* and the markings of *A. excisa*.

Length hardly 0.27 mm. Motion active. The specimen figured contained a single large ovum. The head may possibly have been somewhat protruded by pressure. Habitat, vicinity of Minneapolis.

*Alonella excisa Fischer.

PLATES XXII, FIG. 10; LXI, FIGS. 6-7; LXIII, FIGS. 10, 11.

Lynceus excisus—Fischer.
Pleuroxus excisus—Schoedler.
? Pleuroxus insculptus—Birge.

This species is closely allied to *Alonella exigua*; yet that species shows appreciable differences (which can hardly be claimed, perhaps, for *Pleuroxus insculptus*). The various authors who have written of this *Lynceid* have all laid emphasis upon the sculpture of the shell, almost to the exclusion of other points in the description. Professor Birge has found a quite different form, apparently, which has the same peculiar markings; and even the common *Alona oblonga* has a part of the valves covered by minute striations. Schoedler's figure of this species is unrecognizable; but, as identified by Kurz, the species seems undoubtedly the same that is common in shallow pools in Minnesota, during autumn, and probably also in Massachusetts.

The variations to which this species is subject are considerable and may account for the marked disagreement in the accounts of our different authors. Schoedler gives his specimens a length of 0.20 to 0.25 mm., while Kurz says 0.35 mm. Birge gives 0.27 mm. for the length of *Pleuroxus insculptus*, and our specimens varied in the same gathering between 0.24 mm. and 0.40 mm. Schoedler figures three teeth at the lower posterior angle; Kurz says "several (4)"; Birge describes one or two, and Minnesota specimens show gradual transitions from an inconspicuous angle to three or perhaps four teeth. These teeth are the extensions of some of the strong ridges or crenulations which mark the shell. P. E. Mueller's figures of the shell and abdomen of *P. exigua* would apply to our species perfectly, save the absence of minute striations; Kurz's statements with reference to the differences between these two forms seem to agree only in part with those of

Schoedler. I must here express my suspicion that the *Pleuroxus aculeatus*, *P. exiguus* and *P. excisus* all belong under this species. I have seen a small form which lacked the fine striations; and there appeared to me to be, at times, a slight indication of a second series of hairs upon the post-abdomen.

The form is oblong, truncate behind, variously arched above, but usually with a rather low, evenly curved dorsal contour; the lower shell margin is either nearly straight or convex in front and concave along the posterior third, and is heavily beset with very long pectinate bristles. The head is moderately depressed, with a very broad, blunt and short beak (in some positions this beak seems acute, but it is an optical delusion); the fornices are very broad, covering the antennules completely; seen from above the head is broad and truncate in front; the eye is larger than the large pigment fleck, which is nearer it than the end of the beak. The antennæ have eight setæ, the last of which is minute; the five spined ramus has a strong thorn on the end, and the inner terminal seta is reduced. The post abdomen is rather broad and truncate or somewhat rounded below; its length is very variable, being short in small individuals; its form is subject to concomitant variations. The seven to eleven anal spines extend in a series of minute bristles above the anus. The lower posterior angle of the shell bears one to four teeth; the marking consists of wavy ridges and striæ, producing, by the crossing of two sets springing from the two lower angles, a reticulation covering more or less of the entire shell. The head-shield and the spaces between these markings are densely striated. Color yellowish, often opaque. Length 0.24 to 0.40 mm. At times abundant. Birge alone has seen the males; his description agrees with Kurz's account of the male of *A. exigua*, save that the former speaks of spines, and the latter of thorns, along the post abdomen.

Alonella exigua Lilljeborg.

Lynceus exiguus—Lilljeborg, Leydig, Fric.
Pleuroxus exiguus—Schoedler, P. E. Mueller.
? *Lynceus aculeatus*—Fischer.

Aside from the differences in the male sex as above indicated, this form is said to have a convex lower margin, a rounded post-abdomen, and the pigment fleck nearer the end of the beak than the eye. The absence of the fine striation, finally, is the most marked characteristic. Length 0.30 to 0.33 mm. Not identified in America.

(?) **Alonella grisea** Fischer.

This species is included here on the authority of Kurz. The shell may or may not be toothed at the lower corner, and is partly lined and partly reticulate; but the only character which at all separates this

species from the above seems to be the position and form of the head, which is said to be blunt and nearly horizontal, as in *Camptocercus rectirostris*. Is this a transition to *Graptoleberis?*

***Alonella pygmæa** Sars.

PLATE LX, FIG. 7.

Pleuroxus transversus—Schoedler.
Alona transversa—P. E. Mueller.
Lynceus nanus—Fric.
Alonella pygmæa—Kurz.

The form is rotund, much like species of *Chydorus* in the highly arched dorsal outline; the beak is rather short and depressed; the lower outline of the valves is very convex in front, and barely sinuate behind, where it terminates in a minute spine. The shell is marked, as in no other *Lynceid*, by lines running diagonally backward, and only on the lower part reticulated, if at all.

The post-abdomen is short, broad and rounded below; the claw has a single basal spine. Length 0.20 to 0.28 mm. This is the smallest member of the *Cladocera*. In form it so nearly resembles *Chydorus* that upon first sight the writer took it for a member of that genus. Our one specimen measured 0.25 mm. The shell is marked by plications rather than striæ, which arch over the back.

Alonella striata Schoedler.

This species is said to resemble *A. exigua* in habit and sculpture of shell; the form is quadrangular and not greatly elevated in the middle; the lower margin is nearly straight and fringed with bristles; the posterior angle is rounded and unarmed. The antennules with their setæ extend beyond the beak; the pigment fleck is smaller than the eye and half way to the beak. The post-abdomen is long and narrowed toward the end; there are seven or eight anal spines, and two spines on the terminal claw. Length about 0.5 mm.

SUB-GENUS PLEUROXUS.

Section A, **Pleuroxus (verus)** Baird.

This group of Lynceids is most obviously defined by the long beak, formed by the extension of the chitinous covering of the head. (There is rarely a beak in the sense of that word as applied in the case of *Scapholeberis* or *Daphnia*, but the antennules are simply attached to low prominences on the under side of a broad shield-like projection of the shell.) This beak-like projection is acute and often long and either curved backward or even bent forward. The fornices, or lateral

projection of the head-shield, are narrow. The form varies much, but is almost always very strongly convex above, and the posterior margin is thus only a fraction of the whole height of the animal. In some American species the body is very much elongate, and these also depart from the characteristic habitus of the genus in having strong longitudinal striæ instead of reticulations. The lower posterior shell angle has teeth which, in a few cases, extend across the entire posterior margin. The post-abdomen is slender, usually truncate and armed behind with a single set of sharp teeth on either side; the terminal claw has usually two spines and may be serrate.

The male has a shorter beak, the post-abdomen is more or less modified, and the first foot has a powerful hook. The winter eggs frequently have a true ephippium; and sometimes this structure is like that of *Chydorus*, toward which the round forms of this genus seem to lead. There are upwards of a dozen valid species, several of which are American.

KEY TO PLEUROXUS VERUS.

Beak not curved forward.

A. Shell reticulate. . . . . **hastatus,** 254; (?) **stramineus,** 255
B. Shell smooth, except upon the front margin. . . . . **aduncus,** 255
C. Shell striped.
a. Shell very long and low.
* With one tooth below. . . . . **gracilis,** 257
** Without a tooth; female with a hook upon the first foot. **hamatus,** 257
b. Shell high.
* The whole posterior margin of the shell spined. . . . **truncata,** 258
** The lower angle of the shell spined.
† Antennæ with eight setæ; the anterior margin of the valves toothed. . . . . **denticulatus,** 256
†† Antennæ with seven setæ. . . . . **bairdii,** 256

Beak procurved (Rhypophilus).

A. Shell reticulate (either strongly or quite faintly). . . . **personatus,** 259
B. Shell striped.
a. The posterior margin of the shell toothed. . . . . **procurvus,** 258
b. Only the lower angle of the shell toothed. . . . . **uncinatus,** 259

(Not noticed in the key. . . . . **trigonellus,** 255)

Pleuroxus hastatus Sars.

PLATE LXII, FIG. 16.

Pleuroxus lævis—Sars.

Form somewhat oval, dorsal line strongly curved, posterior margin short, with a tooth below: head short, beak very long, straightish; shell obscurely reticulate. Post-abdomen very long, narrow,

with small teeth; claw with two basal spines. Color corneous. The sculpture consists of faint reticulations. The ephippium forms a truncation of the upper part of the shell. Length 0.50 to 0.55 mm. The male has a shorter beak; the first foot has a weak hook; and the spermatozoa are spherical.

Pleuroxus straminеus Birge.

This form is the American representative of the preceding, if not identical with it. Birge mentions minute striæ in the meshes. *P. straminеus* is said to be lower than *P. hastatus*, while its beak is shorter. Undoubted specimens of *P. denticulatus* exhibit the same differences, an increase in the convexity of the shell accompanying an increase in the length of beak. The form of the abdomen appears nearly identical, if we compare P. E. Mueller's Plate IV, Fig. 18, with the outline given by Birge at Plate II, Fig. 11. The color in both is deep, especially during the period when the winter egg is forming. The direction of the reticulations is said to differ, but P. E. Mueller's figure does not furnish positive evidence of this. Length 0.6 mm.

Pleuroxus trigonellus O. F. Müller.

Lynceus trigonellus—O. F. Müller, Lievin, Lilljeborg, Leydig, Fric.
? Pleuroxus ornatus—Schoedler.

Dorsal line strongly arched; the beak rather long, straightish, pigment fleck smaller than the eye. Shell faintly reticulate, the markings consisting of transparent ridges. Post-abdomen widest in the middle, attenuated slightly toward the end, which is truncate; claw large, with one long and one very small basal spine. The anal margin of the post-abdomen has a series of small spines, and the lower shell-margin is hairy. The post-abdomen of the male is somewhat as in *Crepidocercus*, and densely hairy; the first foot has a moderate hook.

To judge from Kurz's statements, *P. ornatus* Schoedler is not specifically distinct. Not yet identified in America.

Pleuroxus aduncus Jurine.

Monoculus aduncus—Jurine.

Very like *P. trigonellus*, but with the back more strongly arched. The anterior part of the shell is striped. The beak is shorter than in *P. trigonellus*, but no other permanent differences are discoverable. The temptation to believe this a mere varietal form of *P. trigonellus* is great. Indeed, four species (the two here noted, *P. bairdii* and *P. denticulatus* Birge) are very nearly related. The ephippium, where known, is marked by minute punctation and a darker color.

Pleuroxus bairdii Schoedler.

Pleuroxus trigonellus—Baird.

This form, so far as can be gathered from Baird's brief description and figures, differs from the others in having the shell marked by straight parallel lines running diagonally back and upwards, and in lacking one of the terminal bristles on the 5-setose ramus of the antennæ. The first is a possible but unusual structure, while the second might result from an overlooking of the very small seta which fills this place in the other forms. Baird himself did not distinguish it from *P. trigonellus*.

***Pleuroxus denticulatus** Birge.

PLATES XLV, FIG. 8; LXIII, FIGS. 10a, 12, 13.

Resembling very closely *P. aduncus*, which, however, has a broader post-abdomen than the ordinary *P. denticulatus*. The posterior angle of the shell is armed with from one to four (generally three) teeth. The beak is very long.

The character most emphasized by Birge is a series of teeth along the anterior margin of the valves. The same thing is found in *P. procurvus*, as I have repeatedly satisfied myself. In certain positions these teeth do not show, or the smaller teeth on the lower margin only appear. *P. aduncus*, as figured by Schoedler, has similar teeth on the lower margin, and very likely has them anteriorly. The edges of the valves are heavily fringed with pectinate setæ. The male has a shorter beak and the post-abdomen simply rounded without the peculiar modifications seen in *P. aduncus*.

There seems to be two varieties in Minnesota, both of which have the characteristic irregular striations, which radiate from an irregularly marked or unmarked area in the centre of the shell toward the edges; both have the toothed posterior angle and the serrated posterior angle and the serrated anterior margin. But the common form is much longer, with the dorsal margin less convex and the beak shorter. The robust form has a larger pigment fleck, while the post-abdomen is shorter and more robust, resembling more nearly Schoedler's figures of the abdomen of *P. aduncus*. There is another variation or abnormality, in which the lower margin is quite concave. The resemblance to *P. procurvus* is remarkable in some phases.

I have collected this species in Blount springs, Ala., in the St. Croix river, and at various intermediate points, as well as very often in Minnesota.

*Pleuróxus hamatus Birge.

PLATE LX, FIG. 1.

This species is smaller than those of the preceding group and forms a transition to the two next, to be described, in the greater elongation of the shell, which is, however, higher and more strongly arched. The head and beak are much as in *P. denticulatus*. The lower margin is concave posterior to the middle and slightly convex at the posterior angle, which is unarmed. The lower margin is hairy. The markings are as in *P. denticulatus*, but, in addition, there is a set of horizontal striæ all over the shell. The post-abdomen is widest in the middle and almost exactly as in *P. denticulatus*. The first foot bears a claw such as ordinarily distinguishes the males.

The only specimens which I have seen were from the Tennessee river, near Waterloo, and near Decatur, in Alabama. My notes contain no reference to the minute striations, which could perhaps be hardly seen with the instrument employed. The process of the labrum is long and rather acute, the beak moderate, and the pigment fleck very large. The markings on the anterior of the valves are irregular and are inter-connected by cross lines or anastomoses. Ova two. (The genus *Anchistropus* has a hook upon the first foot, but is like *Chydorus*.)

*Pleuroxus gracilis Hudendorff.

PLATE LXIV, FIGS. 15, 15a.

Pleuroxus unidens—Birge.

An extreme among these elongated species, the length of body falling little short of double the height. The dorsal line is very flat and slightly but evenly arched; the lower margin is evenly convex or nearly straight, covered by long pectinate bristles. The head is short, and the beak is long and sharp; the antennules are of moderate size, with a lateral seta one-fourth from the end; pigment fleck less than the eye; antennæ rather long, with strong thorns on the terminal joints. The post-abdomen is long, as in *P. hastatus*, sides nearly parallel; anal teeth sharp, small and numerous; claws pectinate, with two strong basal spines. The shell is strongly striate with longitudinal striæ, which are parallel with the different margins. Birge says that there is a reticulated area. The lower angle is rounded, and anterior to it is a small tooth directed backward. This species is distributed throughout the Mississippi valley. I have notes of it from Swan lake, near Decatur, Ala. It is often rather abundant about Minneapolis, but it is thought by Birge to be absent from the Eastern states. Almost all the specimens I have seen are very dark, often brown, so as to appear to the eye like dark specks as they swim about. The length

varies from 0.55 mm. to 0.85 mm. About 0.60 mm. is a common size, according to my observation. Birge mentions a rudimentary sixth foot in this species. This organ is found in *Eurycercus* and other *Lynceids*, according to Schoedler.

Pleuroxus truncata O. F. Müller.

Lynceus truncatus—Müller, Koch, Zaddach, Lievin, Fischer, Lilljeborg, Leydig, Fric.
Percantha truncata—Baird, Schoedler, Kurz.
Pleuroxus truncatus—P. E. Mueller.
Percantha brevirostris—Schoedler.

This species is widely distributed in Europe, but is replaced in America by the following. The shell is high, the dorsal contour arched; beak rather long and straight; lower margin slightly convex, setose; posterior margin straight, armed with very strong teeth entirely across it: the anterior margin also is dentate, as in the next. The valves are covered with strong striæ, springing from the anterio-central part and radiating toward the free margins. The post-abdomen is of moderate size and in form much as in the next. The ephippium causes a considerable change in form and coloration. In the male the beak is shorter, and the abdomen has finer teeth. The first foot has an extraordinarily large hook. The length is about 0.5 mm. to 0.6 mm. *Percantha brevirostris* Schoedler differs in the length of the beak only.

* **Pleuroxus procurvus** Birge.

PLATE LXI, FIGS. 3, 4.

In size and general appearance this most interesting species is similar to the above, and, especially, to *P. denticulatus*. The general form and even the details of structure agree almost to identity with the latter. The structure of the posterior margin is like *Percantha*, while the rostrum is bent abruptly upwards as in *Rhypophilus*. In small individuals the length is greater proportionally. The lower margin is slightly convex or nearly straight, and fringed by bristles which are strongly pectinate; the anterior and lower margins are toothed as in *Percantha*. The shell gland is more as in the *Daphnidæ* than most *Lynceids*. The number of posterior teeth is variable. The ephippium is as in *P. denticulatus*. Length 0.40 mm. to 0.50 mm. Not rare, but less common than *P. denticulatus*. The male post-abdomen is like that of *P. denticulatus;* the rostrum is as in the female.

Of the species following it may suffice to say that they are corpulent, filth-loving representatives of *P. trigonellus*, *P. aduncus* and *P. bairdii*, respectively, which have turned up their noses at a superficial existence and buried themselves in the mire and debris at the bottom of the pools. It might be fanciful to assume that the curved snout is used for "rooting," but the fact that these "Schmutzpeterchen" *Lynceids* would find a long straight beak in the way is suggestive.

Pleuroxus personatus Leydig.

Leydig '60 (Lynceus personatus); Schoedler '62, '63 (Rhypophilus personatus and glaber); Norman and Brady '67 (Lynceus uncinatus); Müller '68; Fric '72 (Lynceus personatus); Hellich '77 (personatus and glaber); Herrick '84; Daday '88; Matile '90; Kurz '74 (glaber).

Shell high, oval, smaller caudad. Head small, depressed, with narrow, long, procurved beak. Macula quadrangular, half the size of the eye, to which it is nearer by half than to the end of the beak. The shell is either hexagonally reticulate or smooth. The lower margin is flexed cephalad of the middle and bears long cilia. The ventro-caudal angle bears two curved spines. The post-abdomen is rather broad, narrowed toward the end. Anal teeth 10-11, very large. Claw serrate, and with two basal spines. There are seven setæ and a spine upon the antennæ. The antennules are fusiform. Length 0.65 to 0.67 mm.

There seems to be no reason to doubt that *P. glaber* is only a condition of *P. personatus* not even worthy of a varietal name.

Pleuroxus (*Rhypophilus*) **uncinatus** Baird.

The shell is ridged with lines running upward and backward, as in *P. bairdii;* the lower angle of the shell has three teeth, and the beak is more horizontal than in the above. In size and characters this is almost identical with *P. bairdii*, with which it occurs in England.

This completes the list of swine-like members of the genus; these well deserve to be studied from a morphological standpoint.

The following names may be mentioned, though the list of synonyms cannot claim to be exhaustive.

Pleuroxus nasutus Gay is a poorly described form from Chili, resembling, according to Schoedler, *P. ornatus = trigonellus.*

A species of *Percantha* (*Lynceus armatus* Gay) is found in Chili.

P. exiguus Lillj. is *Alonella.*

P. griseus is possibly *Alonella pygmæa* but is said to have two teeth on the ventro-caudal angle of the shell which is faintly reticulated as well as striate.

P. striatus Hellich is *P. gracilis* Hudendorff.

P. striatus Schoedler is *Alonella.*

P. balatonicus Daday is insufficiently described.

P. excisus Fischer is *Alonella.*

P. nanus Baird is *Alonella pygmæa.*

P. lævis Sars is *P. hastatus.*

P. ornatus Schoedler is the young of *P. trigonellus.*

P. trigonellus Mueller is *P. bairdii* Schoedler.

P. glaber Schoedler is *P. personatus*.
P. brevirostris Schoedler is P. *truncatus*.
P. aculeatus Fischer is *Alonella exigua*.
P. convexus Poggenpol is doubtful.

SECTION B. *Leptorhynchus* Herrick.[1]—The species for which Sars formed the genus *Harporhynchus* is of *Alona*-like habit, but has a beak which exceeds that of any known *Pleuroxus* in length, being simulated in this respect by the American *P. acutirostris*, which is, however, in other respects more nearly allied to *Pleuroxus*.

Leptorhynchus falcatus Sars.

Harporhynchus falcatus—Sars.
Alona falcata—Sars, P. E. Mueller.

Body oblong, arched above; ventral margin nearly straight, setose, with a spine at the posterior angle; beak strongly curved, folded laterally; pigment spot larger than the eye. The post-abdomen is wide, sides nearly parallel, armed with a few strong teeth below and a lateral line of spines; caudal claw with a single small basal spine.

GENUS CHYDORUS Leach.

This genus, if it be really of generic value, contains minute rotund animals which appear in the water like animate pin-heads of small size. Their motion is a rolling, wavering hobble; and they live by preference upon vegetation, or in slime at the bottom of pools. Occasionally they may be seen in sunshiny weather, disporting themselves near the surface in immense numbers. There are two common species, and six more which are more rare or in part not valid.

The sexual period occurs at two different periods (i. e., May-June and December), but probably is not confined to any periods. The males, which only rarely are found even in these periods, have the abdomen narrowed or excavated to accommodate it to the peculiar alteration of the brood cavity which takes place in the sexually mature female. The connection takes place by the insertion of the abdomen within this chamber, which is facilitated by the reduced size of the abdomen. The modification of the shell of the brood-cavity above referred to consists in the thickening of the wall posteriorly, which may or may not result in the deforming of the shell as shown in Plate LXIV, Fig. 7, taken from Kurz. This may be termed an ephippium, although it differs somewhat from the modified shell so called in *Daphnia*. The male element consists of nearly round nucleated cells, and the opening of the vas deferens is anterior to the terminal claws.

1 *Harporhynochus* is preoccupied in ornithology.

The members of this genus are among the most minute forms of the family or the entire group. Concisely put, the characters are as follows:

Form globose, not obviously truncate behind; head terminating in a sharp, long, curved beak, which lies close upon the anterior margins of the valves; antennæ short; eye larger than the pigment fleck; abdomen flattened, excavated in the male; intestine with no anterior cæca, doubly convoluted, with an anal cæcum. Three species found in Minnesota.

* Chydorus sphæricus Mueller.

PLATE LXIV, FIGS. 4, 7, 8, 10.

Lynceus sphæricus—O. F. Müller, M. Edwards, Koch, Zaddach, Lieven, Fischer, Lilljeborg, Leydig, Toth, Zenker, Fric.
Monoculus sphæricus—Jurine.
Chydorus muelleri—Leach.

Form nearly spherical, as seen from above broadly oval; in young specimens truncate behind; antennules of moderate size, in the male very large, with curved flagellum near the middle of anterior margin; pigment fleck often nearly as large as eye; beak of moderate length, blunt in the male; first foot strongly hooked in the male; post-abdomen short, broad, rounded at the end, armed with eight or nine sharp teeth; shell reticulated with polygonal meshes. Color light, unspotted. Length 0.50 mm.

This species occurs in spring earlier than most forms, and is ranked as the most abundant of the micro crustacea, being found over the whole circumpolar land-area. The ephippium for the winter egg was observed by Kurz, but the period at which it is formed seems variable.

C. sphæricus of a previous report seems to have been the following species, which is more common in Minnesota in the clearer lakes. A small form in our large lakes measures 0.3 mm.; it may be distinct.

* Chydorus globosus Baird.

PLATES XXI, FIG. 23; LXIV, FIGS. 1-3, 9.

Form globose, very broad; antennules very large with a strong lateral seta on a small elevation; swimming antennæ exceedingly small; the shell gland is well developed; the pigment fleck is much smaller than the eye; beak very long and incurved; post-abdomen rather long, more slender than the last, broader near the end which is truncate, bearing about 20 spines on the margin near which is a lateral series of minute bristles; the terminal claws are straightish, spined along the basal half, and have an accessory spine; the shell is very indistinctly

reticulated and spotted; color dark; length 0.7 to 0.8 mm.; male 0.55 mm. The males have the abdomen very narrow for the entire length.

This species is considered rare elsewhere, but is not infrequent near Minneapolis during August.

Chydorus ovalis Kurz.

PLATE LXIV, FIG. 11.

Form oval, nearly twice as long as high; beak long; antennules two-thirds as long as the beak, with one elongated sensory filament above the others; pigment fleck nearly as large as the eye; antennæ small; shell margins heavily fringed anteriorly; post-abdomen of moderate size, rounded at the end, with about eight teeth near the end; shell smooth. Length 0.4 mm.

This species is rather near *C. sphæricus*, differing in having the shell smooth, antennæ shorter and beak longer. This species is not yet known in America. From *C. latus* it differs in the single antennulary flagellum and number of anal teeth.

* **Chydorus cælatus** Schoedler.

PLATE LXIV, FIG. 12.

Chydorus aduncus—Schoedler.

This small species is about 0.4 mm. long and resembles the young of *C. globosus* in form, from which as well as from all known species it is distinguished by the markings of the shell, which consist of series of rounded elevations (or depressions?) arranged parallel to the lower margins of the shell and head. The description is very incomplete, and the only other author who appears to have seen the animal is Kurz, who adds that the sensory filaments of the antennæ are unequal in height, and that the so-called elevations are really depressions. A form with a few depressions about the edge and characters of this species was once seen in the vicinity of Minneapolis. This is probably a variety of *C. sphæricus*.

Chydorus nitidus Schoedler.

PLATE LXIV, FIGS. 5, 6.

Shell smooth and regularly punctate; the head resembles *C. sphæricus*, but the pigment fleck is much smaller than the eye, to which it is much nearer than to the end of the beak; the post-abdomen is broader near the end, and bears a row of 10 to 12 teeth on either side.

Chydorus latus Sars.

Of moderate size, oval, rounded behind. A slight depression between head and body. Beak long, slender and curved. Macula quad-

rangular, smaller than the eye and half as far from it as from the beak. The conical antennules bear two flagella, one near the end, the other near the basal third. Shell longer than high, strongly arched above, surface smooth. Anal teeth 13 or 14. Claws short and smooth except for the two basal spines. (Matile says the claws are slightly ciliate.) Length 0.54 to 0.59 mm.

Chydorus piger Sars.

Sub-rotund, prominent above, sinuate behind; lower and posterior margins rounded, lower margin ciliated. Head movably united to the body; beak long, separated by an indentation from the head shield. The shell is broad, as seen from above. Shell punctate anteriorly and marked below by indistinct oblique striæ. Antennules with seven setæ and two small thorns on the end of each ramus. Post-abdomen truncate; the terminal claws with a minute tooth at the base, posterior margin sinuated, rounded below and there densely armed with minute teeth. Abdominal setæ long and flexible. Pigment fleck of medium size, much nearer to the eye than to the beak. Length about 0.33 mm.

(?) **Chydorus latifrons** Dana.

(U. S. Exploring Expedition, Rep. on Crust., Vol. II, p. 1274.)

Very tumid; inside view rotund, head not separate, very short-beaked; beak slender and close to the body, acute; in upper view animal very broad, truncate anteriorly, the front thereby nearly as broad as the body; behind low, triangular and obtuse. Feejee Islands.

(?) **Chydorus albicans** Gay.

From Chili. Is imperfectly described; but it is interesting to note the occurrence of this genus there.

Chydorus punctatus Hellich.

Very small, tumid, truncate caudad. Head low, with rather short, sharp beak. Macula round, as large as the eye, to which it is nearer than the beak. Antennules tumid at the middle, with lateral seta above the middle. The ventral margin of the shell is very convex, with long pectinate setæ. Hexagonal reticulations, each with a central elevation (?) mark the shell. Post-abdomen short, broad. Anal teeth eight or nine, of uniform size. Claw with one basal spine and a row of setæ. Length 0.44 to 0.47 mm. The abdomen of the male is curved and deeply excavated apically. Claws short and smooth. Length 0.42 mm. This is probably only a variety of *C. sphæricus*.

Chydorus letourneuxi Richard.

Richard '88.

Testa a latera visa subrotundata, sulcis curvatis (10-12) e medio exeuntibus, ad margines anticos liberos porrectis, antice manifestis ut in *Pleuroxus aduncus*, ornato; testis cetera lævis, margine superiore prominente, postice leviter sinuato, marginalibus posterioribus et inferioribus rotundatis. Valoulorum margines inferiores postice ciliis longis instructi, margines superiores dentati. Rostrum breve et obtusum. Antennæ 1 mi paris ad basin crassæ, rostro breviores, setis æqualibus. Antennæ 2 di paris setis 7 prædítæ. Macula nigra oculo duplo minor, inter oculum et apicem rostri fere in medio sita. Postabdomen apicem versus rotundatum, unguibus terminalibus brevibus lævibus ac robustis, aculeis ad basin 2, quorum interior altero multo brevior, armatis; margo superior in medio sinuatus supra medium processum obtusum format et infra hunc aculeis minutis dense obsitus. Spinulis minutissimis sparsim in lateribus post-abdomen instructum. Color corneus. Longit. circit 0.5 mm. Mas ignotus. Algeria and Tunis.

Chydorus alexandrowii and *C. tuberculatus* of Poggenpol are confessedly imperfectly described. We incline to the belief that there are not more than four good species in this genus, but extended study of the conditions of variation are necessary.

GENUS ANCHISTROPUS Sars. (?)

Very similar in form to *Chydorus:* valves gaping below anteriorly; antennules small; process of labrum rounded. Post-abdomen attenuated toward the end, densely covered with fine teeth; terminal claws denticulate. First foot with a powerful claw, protruding beyond the shell. Eye very large. Shell indistinctly reticulate. Sars says of his *Anchistropus emarginatus* that on cursory inspection it would be taken for the young of *Chydorus globosus*. He found but few specimens, about 0.35 mm. long. The suggestion is still possible that the young males of some *Chydorus* are here mistaken for a new genus. The males of *Chydorus globosus* were not known till 1878, and their early form is still unknown. The young females have a tolerably strong claw, though it is not much curved. I once found a peculiar *Lynceid* measuring 0.46 mm., with unevenly but distinctly reticulate shell, slender abdomen, and a strong claw which was dentate. There were several young (more than two), and the shell in these was more regularly reticulate. All efforts to find a second specimen failed, and the one seen was somewhat mutilated; hence I am unable to determine its real position.

GENUS MONOSPILUS Sars.

Head separated by a depression from the body; shell high, compressed, posterior margin somewhat less than the greatest height of the shell. Post-abdomen broad, ornamented with lateral and posterior

spines; claws large, with a single basal tooth. The compound eye is absent, its place being taken by the pigment fleck, which is the functional eye.*

*Monospilus tenuirostris Fischer.

PLATE LXII, FIG. 21, 21a.

Fischer '54 (Lynceus tenuirostris); Sars '61; Norman and Brady '67; Mueller '68; Hellich '77; Herrick '84 and '87 (dispar).

Shell roundish; ventral margin setose; posterior angle rounded, marked above with numerous impressions. Antennules small; antennæ long, with seven setæ. Post-abdomen short and broad, bearing a series of spines along the excavated posterior margin, and ornamented on the sides with clusters of bristles. The shell in old individuals is not moulted but remains as in *Ilyocryptus*, covering the greater part of the new shell. The figure shows an old individual with its successive coverings still clinging to it. Like *Ilyocryptus*, this animal passes its life in filth at the bottom of pools and rarely emerges to the light of day. What little visual function there may be is vested in the larval organ.

The specimen from which the drawing was made measured 0.45 mm. The first glance at this rarest of all entomostraca affords proof of its unique character. The strongly arched shell is so compressed as to bear little resemblance to *Chydorus*. The dorsal line passes with little angle into the high posterior margin. There is a rounded angle below, armed with two teeth—the shortened representatives of the fringing spines of the straight lower margin. The head is depressed and very short; but the narrow beak is produced to below the margin of the valves. It is rounded so as to resemble, as seen in front, a duck's bill. The fornices are narrow and flare so that the eye is left partly exposed upon the side. The antennules are not long but slender. The labrum has a very large lamella, which is crenulate in front and acute below, the labrum proper being large. The systematic position of this genus is a matter of considerable interest, for it is the only member of the whole order in which the larval eye is the only one

*So much interest attaches to this species that we reproduce the latin description of Sars: "Testa in adultibus valvulis composita pluribus, altera alteri imposita, a latere visa lata, latitudine maxima in parte antica sita; margine superiore antice valde prominente, posteriore et inferiore ciliato rotundatis. Caput mobile, perparvum et valde depressum, supine impressione parva sed distincta, a testa cetera disjunctum, deorsum in rostrum rectum et breve apice obtuso exiens. Animal supra visum sat compressum, latitudine maxima capite majore ante medium sita. Pars superior testæ et capitis impressionibus numerosis rotundatis notata. Antennæ 1-mi paris minutæ structura ut in ceteris Lynceidis; 2-di paris sat longæ, ramo altero setas 4 et aculeum unum apicalem altero setas 3 et aculeos duos, quorum alter longus articulo primo ejusdem rami adfixus est, gerunte. Postabdomen breve et latum, apicem versus truncatum; margine posteriore supra obtuse angulato, ad angulum inferiorem rotundatum seriebus duabus aculeorum inque lateribus setis vel spinulis brevibus numerosis præditum; ungues terminales ad basin aculeo longo armati. Intestinum, ut in ceteris Lynceidis, in thorace laquem fere duplicem format. Macula nigra unica minima prope basin antennarum 2-di paris; maculæ infra oculari in ceteris Lynceidis simillima, in capite conspicitur, quæ, quum oculus verus compositus in omnibus ceteris Crustaceis Cladoceris distinctus omnino absit, organum quamquam rudimentare visus habenda est. Animal parum pellucidum, colore fulvescente. Longit. parum supra $\frac{1}{3}$ mm."

developed, and the first thought would be that this must be a primitive synthetic type; in other words, historically the oldest of *Cladocera*. Closer study does not warrant the theory. There is much to indicate that, though essentially lynceid, it stands in close connection with the higher members of the family and perhaps has more than a superficial resemblance to such degraded *Lyncodaphnids* as *Ilyocryptus*. All things considered, however, our diagram stands with this genus as a degraded offshoot of the more typical stem of *Lynceidæ*.

SUB-ORDER GYMNOMERA.

This group is easily recognized by the almost entire absence of the shell, which forms so conspicuous a part in the greater number of the *Cladocera*. Here it serves simply to form a pouch or brood-sac for carrying the eggs and embryos. The feet are nearly terete and prehensile, with but slight indications of branchial appendages.

FAMILY POLYPHEMIDÆ.

Feet five pairs. Antennæ with the rami three- or four-jointed.

GENUS POLYPHEMUS De Geer.

Head very large, separated by a depression from the compact body; shell covering but a part of the dorsal region. Feet all with an internal dentate and an external lamellate appendage. Caudal seta upon a long process of the post-abdomen.

* Polyphemus pediculus Linn.

Plates LVIII, Figs. 4-6; LXIX, Fig. 1.

Monoculus pediculus—Linnæus, 1746. Gmelin, Linn. Syst. Nat. Fabricius, Ent. Syst., etc. Sulzer, Insecten. Mannel, Encyclop. Meth.

Monoculus pediculus ramosus—De Geer, Mem. pour serv. a l'Hist. des. Ins.

Polyphemus oculus—Mueller, Zool. Dan. Prod. et Entomost. Cuvier, Tab, element. Latreille, Hist. Nat. Crust., etc. Leach, Edin. Encyc.

Polyphemus stagnorum—Leach, Dict. Sc. Nat. Latreille, Cuv. Reg. An. Demarest, Cons. Gen. Crust.

Polyphemus pediculus—Straus, Mem. Mus. d'Hist., etc. M. Edwards, Hist. Nat. Crust.

Monoculus polyphemus—Jurine, Hist. Nat. Monoc.

Cephaloculus stagnorum—Lamarck, Hist. An. Vert. Bosc, Man. d'Hist. Nat. Crust.

Monoculus oculus—Gmelin, Linn. Syst. Nat.

Scalicerus pediculus—Koch, Deutsch. Crust.

Polyphemus pediculus—Baird, Brit. Entom.

Polyphemus oculus—Lievin, Branch. d. Danz.

Polyphemus stagnorum—Fischer, Ueber die in d. Umg. von. St. Petersburg vorkom Crust.

Polyphemus pediculus—Lilljeborg, De Crust. ex ord. trib.
Polyphemus oculus—Leydig, Naturg. d. Daph.
Polyphemus pediculus—Schoedler, Neue Beitr. zur Naturg. d. Cladoceren.
Polyphemus kochii—Schoedler, Neue Beitr. zur Naturg. d. Cladoceren.
Polyphemus oculus—Schoedler, Neue Beitr. zur Naturg. d. Cladoceren.
Polyphemus pediculus—P. E. Mueller, Danmark's Cladocera. Kurz, Dodekas neuer Cladoceren. Weismann, Beitr. zur Naturg. der Daphnoiden. Birge, Notes on Cladocera.
Polyphemus occidentalis—Herrick.

There are two well-marked varieties of this species: one is found commonly in the clear lakes; the other, which I have only once seen, was found in a very shallow weedy marsh. The difference in size is quite remarkable. Our ordinary form measures less than 1.0 mm. The larger form, including the stylets, is 1.6 mm. The ordinary variety, although highly colored, is yet transparent, while the large variety is deep red and quite opaque. The relationship between the two forms is quite like that maintaining between *Diaptomus stagnalis* and *D. sanguineus*. Some slight structural differences are observable between the two varieties, as in the form of the antennules, yet quite insignificant when compared with the striking difference in size and coloration.

The feet of this species have not been fully figured hitherto and are accordingly given on Plate LXIX. Some minor differences may be noted between these figures and those given by Lund.

*Polyphemus stagnalis Herrick.

In order to make the relation clear between these forms, I add measurements of this species, following each with the corresponding measurement of *P. pediculus* in parenthesis; animals of the same age, as far as possible, being chosen. Head (capsule of eye) 0.3 mm. (0.2 mm.); head and thorax 0.7 mm. (0.45 mm.); abdomen 0.7 mm. (0.56 mm.); caudal stylet 0.36 mm. (0.26 mm.); caudal filaments 0.36 mm. (0.3 mm.) Whole length of antennæ 0.54 mm. (0.42 mm.); first, second and third joints of the three-jointed ramus 0.08, 0.06 and 0.10 mm., respectively. The formation of the resting eggs or "dauer-ei" seems to go on at the same time with the parthenogenetic reproduction.

GENUS BYTHOTREPHES Leydig.

Much like *Polyphemus*, but the external appendage of the feet is rudimentary, and the abdomen extends out into a most enormous spine. The single species is that described by Leydig as *B. longimanus*, which was found in the stomach of *Coregonus wartmanni*. *B. cederströmii* of Schoedler and P. E. Mueller, the latter author now identifies

with the above, and concludes that the supposed differences arose from "l'etat de maceration des exemplaires examines." (*Les Cladoceres des Grands Lacs de la Suisse*, p. 11.) This species may be looked for in the depths of the Great Lakes. (See Plate XXVII, Fig. 10.)

GENUS PODON and GENUS EVADNE.

These are compact oval forms confined to the sea. See Claus, *Zur Kenntniss des Baues der Polyphemiden*, Vienna, 1877, for the best account of the anatomy.

FAMILY LEPTODORIDÆ.

Feet six pairs. Antennæ with both rami four-jointed. Body elongated, not curved, shell very much reduced.

***Leptodora hyalina** Lilljeborg.

PLATE XXXV, FIGS. 6, 7.

The only species, is found rarely in the larger lakes of Europe and America.

See *Bau und Lebenserscheinung von Leptodora hyalina*, Weismann, 1874: also, *Om en dimorph Udvikling samt Generationsvexel hos Leptodora*, G. O. Sars, 1873: also, *Bidrag til Cladocerenes Forplantningshistorie*, P. E. Mueller.

The work of Sars is particularly valuable, showing that the young produced from the winter eggs pass through a metamorphosis not experienced by the summer or parthenogenetic brood. P. E. Mueller mentions the pathological condition induced by the plants of the Saprolegnia.

APPENDIX TO PART II

NOTES ON THE CLADOCERA

OF THE

SOUTHEASTERN PART OF THE UNITED STATES

BY C. H. TURNER

ORDER CLADOCERA.

FAMILY SIDIDÆ.

GENUS SIDA Straus.

Sida crystallina Müller.

Sida crystallina—C. L. Herrick, Final Report on Minn. Crust., p. 20.

Habitat: Cincinnati, Ohio. Rare. Occurs in deep canal basins.

FAMILY DAPHNIDÆ.

GENUS MOINA Baird.

Moina rectirostris Müller.

Moina rectirostris—C. L. Herrick, Final Report on Minn. Crust., p. 34; Pl. A., Figs. 2, 5, 8, 10, 11.

Length of female 0.94 mm.; height 0.63 mm. Habitat: Atlanta, Ga.

Moina paradoxa Weismann.

Moina paradoxa—C. L. Herrick, Final Report on Minn. Crust., p. 34; Pl. A, Figs. 1, 3, 6, 7, 9.

Habitat: Cincinnati, Ohio. During the latter portion of summer this species is very abundant in foul pools.

GENUS CERIODAPHNIA Dana.

Ceriodaphnia consors Birge.

Ceriodaphnia consors—E. A. Birge, Notes on Clad., p. 5; Pl. 1, Figs. 3, 4.

Length 0.55 mm.to 0.61 mm.; height 0.40 mm. The reticulations on the shell are singly contoured. Habitat: Atlanta, Georgia. Winter and summer.

Ceriodaphnia megops Sars.

Ceriodaphnia cristata—E. A. Birge, Notes on Clad., p. 6; Pl. II, Figs. 8, 9.

Length 0.64 mm.; height 0.50 mm. Habitat: Kent county, Delaware; Atlanta, Georgia.

GENUS SCAPHOLEBERIS Schoedler.

Scapholeberis mucronata Müller.

Scapholeberis mucronata—C. L. Herrick, Final Report Minn. Crust., p. 42; Pl. J, Fig. 5.

Habitat: Atlanta, Georgia; Cincinnati, Ohio; Lockland, Ohio. Abundant in shallow grassy ponds and sluggish creeks.

GENUS SIMOCEPHALUS Schoedler.

Simocephalus vetulus Müller.

Simocephalus vetulus—C. L. Herrick, Final Report Minn. Crust., p. 46.

Habitat: Cincinnati, Ohio; Kent county, Delaware.

Simocephalus serrulatus Koch.

Simocephalus americanus—E. A. Birge. Notes on Clad., pp. 6-8; Pl. I, Fig. 6.

Length 1.7 mm. to 1.9 mm.; height 1.43 mm. This species is often covered with vorticellidæ. Habitat: Atlanta, Georgia; Baxley, Georgia; Cincinnati, Ohio; Kent county, Delaware.

GENUS DAPHNIA Schoedler.

Daphnia pulex Müller.

Daphnia pulex—C. L. Herrick, Final Report Minn. Crust., p. 56.

Habitat: Cincinnati, Ohio; Covington, Kentucky. This species is fond of foul water and is often associated with *Moina paradoxa*.

Daphnia longiremus Sars. (?)

Daphnia longiremus Sars—C. L. Herrick, Final Report Minn. Crust., p. 63.

Length 1.70 mm. This is a non-crested, hyaline specimen, marked with rectangular meshes and devoid of pigment fleck. It resembles the species under which I have placed it in all respects excepting siez. I do not consider this alone sufficient to establish a new species. It may, however, be a variety of the above.

FAMILY BOSMINIDÆ.

GENUS BOSMINA Baird.

Bosmina cornuta Jurine.

Bosmina cornuta—E. A. Birge, Notes on Clad., p. 15; Pl. II, Fig. 10.

Length 0.26 mm. Habitat: Tusculum, Ohio. Rare. Found in grassy pools.

Bosmina atlantaensis Turner.

Bosmina atlantaensis—C. H. Turner, Notes on the Clad. of Ga., p. 23; Pl. VII, Figs. 12, 13.

Length 0.46 mm.; height 0.36 mm. Habitat: Atlanta, Georgia. Obtained in the middle of winter from pools that dry up in dry weather.

FAMILY LYNCODAPHNIDÆ.

GENUS MACROTHRIX Baird.

Macrothrix laticornis Jurine.

Macrothrix laticornis—C. L. Herrick, Final Report Minn. Crust., p. 68; Pl. C, Figs. 8, 9.

Length 0.37 mm. to 0.39 mm.; height 0.25 mm. Habitat: Atlanta, Georgia.

GENUS ACANTHOLEBERIS Lilljeborg.

Acantholeberis curvirostris Müller.

Acantholeberis curvirostris—C. L. Herrick, Final Report Minn. Crust., p. 73.

Length 0.97 mm.; height 0.61 mm. Habitat: Baxley, Georgia.

GENUS ILYOCRYPTUS.

Ilyocryptus sordidus Lievin.

European observers have never found more than a few specimens of this species at any one time. At two different times this summer I have found this species in great numbers in the mud at the bottom of a small pool on the Clark University campus at South Atlanta, Georgia. This pool is a tank about four feet deep, fed by a cool spring. At one end a shallow grassy creek flows outward from it. This creek at its origin is less than a foot deep and has a mud bottom. In this creek, at its source, is where the specimens were obtained. The American specimens tally in all essential respects with the European specimens. Habitat: South Atlanta, Georgia.

Ilyocryptus longiremus Sars.

Ilyocryptus longiremus—E. A. Birge, List of Crust. Clad. from Madison, Wis., p. 392; Pl. XIII, Fig. 18.

This species agrees in all essential respects with the species found by Professor Sars in Australia and by Professor Birge in Wisconsin. Habitat: Baxley, Georgia. It seems to be present in almost all of the ponds near Baxley.

This species is very closely related to *Ilyocryptus spinifer* Herrick. At one time I was fully convinced that they were two distinct species,

but the more I study this species the more I am led to believe that this and *I. spinifer* are varieties of one and the same species. If this surmise be true then Professor Herrick's name has precedence.

FAMILY LYNCEIDÆ.

SUB-FAMILY EURYCERCINÆ.

GENUS EURYCERCUS Baird.

Eurycercus lamellatus O. F. Müller.

Eurycercus lamellatus—C. L. Herrick, Final Report Minn. Crust., p. 80; Pl. H, Figs. 5, 6.

Length 1.67 mm.; height 1.16 mm. Habitat: Kent county, Delaware.

SUB-FAMILY LYNCEINÆ.

GENUS CAMPTOCERCUS Baird.

Camptocercus macrurus O. F. Müller.

Camptocercus macrurus—E. A. Birge, Notes on Clad., p. 33.

The specimen here tabulated under this genus is smaller than those found by Professor Birge in Wisconsin and by Professor Herrick in Minnesota; but, since they agree with Professor Herrick's description in all other respects, it is thought that this is the right place for it. Habitat: Lockland, Ohio. Length 0.63 mm.; height 0.42 mm.

GENUS LEYDIGIA Kurz.

Leydigia quadrangularis Leydig.

Leydigia quadrangularis—C. L. Herrick, Final Report Minn. Crust., p. 88; Pl. H, Fig. 4

Length 1.00 mm.; height 0.5 mm. Habitat: Clifton, Ohio; Lockland, Ohio; Atlanta, Georgia.

GENUS DUNHEVIDIA King.

Dunhevidia Setiger Birge.

Crepidocercus setiger—E. A. Birge, Notes on Clad., p. 26; Pl. I, Fig. 18.

Length 0.43 mm.; height 0.31 mm. Habitat: Cincinnati, Ohio.

GENUS ALONA Sars.

Alona quadrangularis Müller.

Alona quadrangularis—C. L. Herrick, Final Report Minn. Crust., p. 97; Pl. E, Figs. 1, 2.

Length 0.76 mm.; height 0.46 mm. In the specimen here assigned to the above named species the pigment fleck is as large as the eye and the spine on the terminal claw of the post-abdomen is pectinate at its base. Habitat: Baxley, Georgia.

Alona affinis Leydig.

Alona affinis—C. L. Herrick, Final Report on Minn. Crust., p. 98; Pl. F, Fig. 14.

Length 0.79 mm.; height 0.46 mm. The specimens here tabulated are smaller than those found by other writers; but since they agree in all essentials with *A. affinis* they are placed here. In all probability they are immature individuals. Habitat: Kent county, Delaware; Fayetteville, Georgia.

Alona porrecta Birge.

Alona porrecta—E. A. Birge, Notes on Clad., p. 29; Pl. I, Fig. 16.

Length 0.37 mm. to 0.58 mm.; height 0.22 mm. to 0.24 mm. Habitat: Atlanta, Georgia; Cincinnati, Ohio.

Alona glacialis Birge.

Alona glacialis—E. A. Birge, Notes on Clad., p. 30.

Habitat: Cincinnati, Ohio. Rare.

Alona intermedia Sars.

Alona intermedia—C. L. Herrick, Final Report Minn. Crust., p. 101; Pl. I, Fig. 15.

Habitat: Cincinnati, Ohio.

GENUS PLEUROXUS Müller.

Pleuroxus acutirostris Birge.

Pleuroxus acutirostris—E. A. Birge, Notes on Clad., p. 23; Pl. II, Fig. 15.

This species seems to be very rare. I have only encountered it once. Then it was associated with *Pleuroxus hamatus* Birge, which it closely resembles in shape. The specimen resembled in all respects the specimens described by Professor Birge. Habitat: Atlanta, Georgia.

Pleuroxus hamatus Birge.

Pleuroxus hamatus—E. A. Birge, Notes on Clad., p. 22; Pl. II, Figs. 13, 14.

Length 0.46 mm. to 0.52 mm.; height 0.23 mm. to 0.33 mm. Habitat: Cincinnati, Ohio; Atlanta, Georgia. In the northern part of Georgia specimens of this species are more plentiful than those of any other member of this genus.

Pleuroxus denticulatus Birge.

Pleuroxus denticulatus—E. A. Birge, Notes on Clad., p. 20; Pl. I, Fig. 21.

Length 0.57 mm.; height 0.43 mm. Habitat: Cincinnati, Ohio; Kent county, Delaware; Atlanta, Georgia.

GENUS CHYDORUS Leach.

Chydorus sphæricus Müller.

Chydorus sphæricus—C. L. Herrick, Final Report Minn. Crust., p. 116; Pl. F, Figs. 4, 7, 8, 10.

Length 0.36 mm. to 0.42 mm.; height 0.31 mm. to 0.36 mm. Habitat: Ohio, Kentucky, West Virginia, Georgia. This species is very abundant. At Atlanta, Georgia, it can be found any time during the year.

FAMILY POLYPHEMIDÆ.

GENUS POLYPHEMUS De Geer.

Polyphemus pediculus De Geer.

Polyphemus pediculus—C. L. Herrick, Final Report on Minn. Crust., p. 121; Pl. B[1], Figs. 4–6.

Habitat: Baxley, Georgia.

PART III

FRESH-WATER OSTRACODA

OF THE UNITED STATES

BY C. H. TURNER

PREFACE.

Perhaps no other class of animals has been so much neglected by scientists as the American *Ostracoda*. With the European *Ostracoda* it is quite different. In Great Britain, Norway, Germany, Böhemia and along the shores of the Mediterranean Sea able naturalists have devoted many years of their life to the study of the *Ostracoda* of their respective countries. A perusal of the bibliography given below will show how well they have done the work. In his late monograph (221) Professor Wenzel Vávra devotes several pages to a historical resumé of the work that has been done upon the European *Ostracoda*. All that has been done upon the recent American *Ostracoda* can be included in a single paragraph, and a small one at that.

The first scientist to study American *Ostracoda* was De Kay (58). In 1844 he described a few specimens from New York. This was followed in 1852 by an article by Professor Dana (57). In 1855 Lubbock (123) published a short article on *South American Ostracoda*. Next comes a paper by Chambers (41) on *Colorado Crustacea*. Between 1879 and 1881 Professor Herrick (83, 84, 85, 86) published several papers on this subject. His paper on "*Alabama Crustacea*" is by far the best article yet published on recent United States *Ostracoda*. Professor Moniez (142) has recently added a paper on Lake Titicaca *Crustacea*. Between 1892 and 1894 the present writer has contributed his mite (212, 213, 214, 215, 216) towards furthering the good cause. In 1893 Forbes (67[a]) published a description of a new species.

The fossil *Ostracoda* have been studied by Jones (89,92) Brady (29) and Ulrich (217).

In the present communication it is proposed to give complete descriptions of all known recent United States *Ostracoda*. In most cases the descriptions are made from dissections made by the writer. When this has not been possible the description of some American author has been incorporated. In all such cases the description is surrounded by quotation marks and the name of the author is mentioned.

I here tender my thanks to Messrs. A. B. Whitby and L. D. Hileland, who have so kindly collected for me material which otherwise would have been inaccessible. Mr. Whitby collected in Texas and southern Georgia, while Mr. Hileland collected in Delaware.

I here acknowledge my great indebtedness to Professor C. L. Herrick, not only for the loan of rare literature and for the use of Plates LX, LXIII, LXIV, but also for the careful drawings of *Cypris albuquerquensis* and for alcoholic specimens.

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INTRODUCTION.

The *Ostracoda* form a well defined division of the *Entomostraca*. Like the *Lamellibranchiata* the body is always enclosed in a bivalve shell, which is closed by powerful abductor muscles. No doubt the casual observer often mistakes the *Ostracoda* for miniature mollusks. Yet the resemblance is all on the surface; for, although the structure of the enclosed *Ostracodan* is quite primitive, yet it is decidedly crustacean.

The body always bears seven pairs of articulated appendages. The first five of these belong to the head; but, in different groups, either or all of the last three of these cephalic appendages may be modified for walking. The last two pairs of members belong to the body and are properly called legs or feet. In some cases, however, (*Cypris*) the last pair of legs is never used for locomotion. In most cases the abdomen bears a pair of appendages, which usually resemble one-jointed legs. Morphologically they probably are legs which have been arrested in their development.

It is thought that a brief resume of the steps by which the *Ostracodes* have been assigned to their present taxonomic position may be of interest.

Linnæus (or Linné) included all of the lower *Crustacea* in his genus *Monoculus*.

O. F. Müller divided the lower *Crustacea* into several genera. Collectively they were called the "*Entomostraca*."

Latreille and Cuvier were the first to separate the *Crustacea* from the *Insecta*. Basing their judgment upon the morphology of the mouth parts, they divided the lower *Crustacea* into two artificial groups, the *Branchiopoda* and the *Poecilopoda*. The first division included the *Phyllopoda* and *Lophyropoda*, while the *Ostracoda* fell into the second division.

Following in the footsteps of Latreille, Milne-Edwards, with the mouth parts for criteria, established an artificial system of classification for the *Crustacea*. Separating the *Copepoda* and *Ostracoda* from Latreille's *Branchiopoda*, he united them in the group *Entomostraca*.

Dana modified slightly Latreille's system.

The first attempt to form a natural system of classification for the lower *Crustacea* was made by Zenker. He separated the *Copepoda*

from the *Ostracoda* and used the name *Entomostraca* as a group name for the *Siphonostoma* and *Lernaeoda*.

Claus used the word *Entomostraca* in a different sense. The *Phyllopoda*, *Ostracoda*, *Copepoda* and *Cirripedia* were collectively called the *Entomostraca*.

Professor G. O. Sars has divided the *Ostracoda* into the following four sections: 1. *Podocopa*, 2. *Myodocopa*, 3. *Cladocopa*, 4. *Platycopa*. All of the members of sections 2, 3 and 4 and a portion of those belonging to section 1 are marine.

Brady and Norman have divided the *Podocopa* into the following families:

Family I.—*Cyprididæ*.
Family II.—*Bairdiidæ*.
Family III.—*Darwinulidæ*.
Family IV.—*Cytheridæ*.
Family V.—*Paradoxostomatidæ*.

This article treats exclusively of the first and third families.

FAMILY CYPRIDIDÆ.

"Shell generally thin and horny; valves equal or but slightly unequal in size, surface usually smooth, or simply punctated; ventral margins more or less sinuated; hinge margins edentulous. Eyes simple, usually confluent, sometimes wanting. Antennules (first antennæ) slender, usually seven-jointed, very flexible, usually provided with a number of long hairs forming a dense brush. Antennæ (second antennæ) pediform, geniculated, four- or five-jointed, clawed at the apex, second joint mostly bearing an apical brush of hairs. Mandibles strong, apex strongly toothed, palp four-jointed, with a setiferous branchial plate at the base. Two pairs of maxillæ, the first pair four-digitate; its external branch distinctly two-jointed, bearing a large setiferous branchial plate; second pair small, composed of a single prehensile lobe and palp, which in the female is generally simple, rarely pediform, is in the male prehensile. Two pairs of feet dissimilar in structure, the anterior pair strong, ambulatory, directed downwards, and having a long curved apical claw; posterior bent backwards within the shell, and not used for motion. Caudal rami usually well developed, elongated, very mobile, and bearing two or three apical claws. Intestine forming two dilations, of which the anterior is provided with cœcal appendages. Generative organs large, and of complex structure, and partly extended within the valves; in the male frequently a whorled sac connected with the testis; copula-

tory organs symmetrical, and of moderate size." (Brady and Norman.)

It is thought that the following modification of Wenzel Vavra's key will serve to differentiate the genera.

KEY TO THE FAMILY CYPRIDIDÆ.

I. The second foot terminates with a cylindrical joint that bears two backwardly directed setæ.
  A. The second foot of the female and the male six-jointed. No branchial plate attached to the second maxillæ. **Notodromas,** 295
  B. The second foot of the female five-jointed and of the male six-jointed. The second maxilla bears a branchial plate.
    a. The branchial plate is feebly developed in the form of two pectinated bristles.
      * The eye is developed. . . . . **Candona,** 298
      ** The eye is absent. . . . . *Typhlocypris.
    b. The branchial plate is developed in the form of three pectinated bristles. . . . . *Candonopsis.
    c. The branchial plate is in the form of six pectinated bristles.
      * The palp of the second maxilla is rudimentary. . *Ilyocypris.
      ** The palp of the second maxilla is normally developed.
        † The terminal joint of the second foot is as long as one-third of the fourth joint. . . . **Cypria,** 304
        †† The terminal joint of the second foot is as long as two-thirds of the fourth joint. . . **Cyclocypris,** 310

II. The second foot terminates in a beak-shaped joint that bears one backwardly directed claw.
  A. Caudal rami are rudimentary. . . . . **Cypridopsis,** 312
  B. Caudal rami are cylindrical with two terminal claws.
    * Natatory setæ of the antennæ short.
      † These setæ not reaching to the tips of the terminal claws. **Erpetocypris,** 315
      †† These setæ not reaching to the base of the terminal claws. *Scottia.
    ** Natatory setæ of the antennæ long, reaching to or beyond the tips of the terminal claws.
      † Parthenogenetic. . . . . **Cypris,** 319
      †† Sexual. . . . . **Cyprinotus,** 329

(*Not noticed in the text.)

In the above table an attempt has been made to tabulate all known freshwater genera of the *Cyprididæ*. The genus *Stenocypris* Sars has been omitted because the data at my disposal do not seem to warrant its separation from the genus *Erpetocypris* Brady and Norman. Of the twelve genera here mentioned, nine have been found in America.

GENUS NOTODROMAS Lilljeborg. 1853.

In shape the shell of the male is quite different from that of the female.

The antennules are seven jointed.

In both males and females the antennæ are six-jointed. The natatory setæ extend to beyond the tips of the terminal claws.

There is no branchial plate on the second maxilla. The palp of this jaw is two-jointed. In the female the distal joint is short and cylindrical, bearing at its apex two short setæ; in the male the distal joint forms a long scythe-shaped appendage.

The second foot is five-jointed, terminating in three setæ, two of which are directed backwards.

The two eyes are not confluent.

The abdominal rami are long and slender. Males are numerous. The cylindrical core of Zenker's organ (verticillate sac) is ornamented with numerous closely set whorls of short stout spines.

Notodromas monacha (O. F. Müller).

PLATE LXXII, FIG. 4-4h.

1785.—*Cypris monacha* O. F. Müller (149), p. 60, Taf. V, Figs 6-8.
1820.—*Monoculus monachus*, Jurine (98), p. 173, Pl. XVIII, Figs. 13-14.
1837.—*Cypris variabilis* Koch (102), H. 10, 3.
1837.— " *lencomela* Koch (102), H. 10, 4.
1837.— " *monacha* Koch (102), H. 11, 1.
1837.— " *bimuricata* Koch (102), H. 11, 2.
1837.— " *nubilosa* Koch (102), H. 12, 4.
1844.— " *monacha* Zaddach (234), p. 31.
1850.— " *monacha* Baird (2), p. 153; Pl. IV, Figs. 1-11.
1851.— " *monacha* Fischer (64), p. 146.
1853.—*Notodroma monachus* Lilljeborg (118), p. 95; Taf. VIII, Figs. 1-25; Taf. XII, Figs. 1 3; Taf. XXV, Fig. 16.
1854.—*Cyprois monacha* Zenker (238), p. 80; Pl. III, C.
1868.— " *monacha* Plateau (169), p. 60; Pl. I, Figs. 22-23.
1868.—*Notodromas monachus* Brady (18), p. 379; Pl. XXIII, Figs. 1-9; Pl. XXXVII, Fig. 3.
1870.—*Notodromas monachus* Heller (81), p. 78.
1872.—*Cypris monacha* Fric (69), p. 228.
1880.—*Notodromas monachus* Robertson (184), p. 22.
1882.— " *monachus* Herrick (85), p. 252.
1885.— " *monachus* Nordquist (155), Pls. I, II and IV.
1887.— " *monachus* Korschagen (104), p. 24.
1888.—*Cyprois monacha* Schwarz (199), p. 11.
1889.—*Notodromas monacha* Brady & Norman (31), p. 96.
1891.— " *monacha* Wenzel Vávra (221), pp. 32-39; Figs. 7 9.

This species does not seem to be as abundant in America as in Europe. I have never encountered it. The figures that accompany this description are Professor Herrick's (86), and the following diagnosis is due to Professor Brady (18):

"MALE.—Carapace obliquely sub-quadrangular, greatest height equal to two thirds of the length, situated in the middle. Anterior

margin broad, rounded at the angles, and expanded into a flattened lamina or flange. Ventral margin straight for about two-thirds of its length, then bending upwards at an obtuse angle. Dorsal margin arched, almost angular in the middle, whence it slopes steeply to the anterior border and with a bold curve towards the posterior extremity, joining the ventral margin at an acute angle. Seen from above, the carapace is ovate, pointed in front, and rounded behind; the greatest breadth in the middle. The ventral surface is bounded by two conspicuous, elevated, arcuate ridges, one at each valve, which together enclose a flattened lozenge-shaped area. Parallel to the contact margin of each valve runs another straight but much less conspicuous ridge, which towards the front curves outward, and joins the external ridge at an acute angle, the union of the two forming a slight elevation, from which a single ridge runs forward, gradually merging in the flattened encircling flange of the anterior border. Seen from the front, the shell is sub-triangular, the sides convex, but flattened, the dorsum forming a flattened arch; the ventral border perfectly flat, and bounded by the projections of the outermost ventral ridges; the inner ridges form also conspicuous projections, which run obliquely upwards and inwards towards the flattened anterior flange. Lucid spots, about six, oblong and irregularly placed, their long diameters pointing transversely across the valve. Surface of the shell smooth and shining, marked by fine impressed lines forming a pattern similar to the imbrications of fish-scales. Color pale greenish or white, transparent, with large and irregularly spread patches of deep olive-green or black.

"FEMALE.—Sub-quadrangular. Anterior border flattened, flanged, forming with the ventral margin a well-marked angle; rounded above. Dorsal margin boldly arched, highest at the posterior third, whence it sweeps round with a deep curve to the postero-ventral angle. Ventral margin straight, slightly rising behind, and terminating in a flattened squamous plate, which projects backwards, with the appearance of a spine. The other aspects are similar to those of the male shell, except that the ventral surface of the left valve has at the posterior extremity of its contact margin a flattened squamous plate, which is received into a corresponding depression of the opposite valve."

Professor Brady (18) states that the branchial plate of the mandibular palp arises from the lower side of the palp, thus differing considerably from other *Cyprididæ*. Professor Vávra (221), however, says that the branchial plate arises from the upper side of the mandibular palp.

"The first foot in both sexes terminates in three curved claws, the central one being the strongest and longest. * * * * * * * *

"The 'glandular mucosa' [Zenker's organ] consists of a central cylinder, closely beset with radiating filaments, arranged in 50 to 60 transverse rows, the whole organ being imbedded in a sort of glairy matrix. The two glands are connected each by an efferent duct with the '*bursa copulatrix*,' an organ of very complicated structure, and consisting of a much convoluted canal (? *vesicula seminalis*), an intromittant organ or *penis*, and two hooked appendages. The whole organ is very dense in structure, consisting probably of chitin, deep brown in color, and, with the 'glandulæ mucosæ,' constitutes a very considerable portion of the male carapace. It should be noted that the '*bursa copulatrix*,' as well as the testis,* is a double organ, one on each side of the median line. The two bursæ lie closely in apposition but are not in organic connection except at the upper margin, where they are held together by a ligamentous tissue. Length $\frac{1}{24}$ in. (1.1 mm.), height $\frac{1}{32}$ in. (0.78 mm.)." Habitat: Minnesota (Herrick '85).

GENUS CANDONA Baird. 1850.

This genus, which was founded by Professor Baird (5) has recently been more restricted by Mr. Wenzel Vávra (221). In this connection the genus is used in Vávra's restricted sense.

In the female the antenna is five-jointed. In the male, owing to a division of the fourth joint, the antenna is six-jointed. At the division between the fourth and fifth joints of the male antenna two characteristic olfactory hairs are situated. The distal extremity of the third joint is not supplied with a brush of natatory setæ. The rudimentary branchial plate of the second maxilla is composed of two, unequal, pectinated setæ, which are attached directly to the basal portion of the maxilla. In the female the palp of this maxilla is two-jointed, and terminates with three unequal pectinated bristles. In the male this palp, which is then unjointed, differs in shape from that of the female.

The second foot, which may be either five or six-jointed, terminates with three setæ; two unequally long, backwardly directed, setæ and one forwardly directed seta.

The strong post-abdomen (abdominal ramus) bears two terminal claws. The seta on the caudal border of the ramus is quite remote from the end. At the origin of this ramus the dorsum of the body terminates in a short seta. The eye is small.

Males are common, larger than the females.

Seven circles of chitinous spines are arranged around the central cylinder of Zenker's organ. The copulative organ is not so complex as that of *Notodromas*.

* Dr. Brady uses testis as a synonym for Zenker's organ. It is now well known that this organ is not the testis.

The absence of natatory setæ from the antennæ prevents the members of this genus from swimming. They creep along the bottom and frequently burrow in the mud or sand.

Candona fabæformis (Fischer.)

PLATES LXXV, FIGS. 10, 11; LXXVI, FIGS. 6, 8.

1851.—*Cypris fabæformis* Fischer (64), p. 146; Pl. III, Fig. 6-16.
1853.—*Candona fabæformis* Lilljeborg (118), p. 207.
1870.— " *diaphana* Brady and Robertson (33), Pl. V, Figs. 1-3.
1889.— " *fabæformis* Brady and Norman (31), p. 103; Pl. IX, Figs. 1-4.
1891.— " *fabæformis* Wenzel Vávra (221), pp. 45-48; Figs. 6, 2; Figs. 12, 1-9; Fig. 13.

Length 1.03 mm. Height 0.49 mm. Width 0.38 mm.

The shell is more than twice as long as high and nearly three times as long as wide. The shell being pellucid, the color of the enclosed body shines through the lorica and gives it a greenish yellow tint.

Viewed from the side the shell of the female is sub-reniform; greatest height situated behind the middle; obtusely and evenly rounded in front, obliquely rounded behind. Ventral margin sinuated.

Viewed from above the shell is compressed, tapering equally and suddenly to the two pointed extremities; sides almost parallel. Near each extremity a process from the left valve overlaps the right. The projection near the caudal extremity is much more pronounced than the other.

The antennæ are stout; the smooth terminal claws are slightly curved and are not quite as long as the combined lengths of the last three joints. Natatory setæ are absent. For the arrangement of setæ consult the figures.

The second foot is six-jointed.

The abdominal rami are strong. In the female they are curved. The terminal claws are stout, curved and pectinate; the shorter claw is a little more than three-fourths as long as the other. The longer claw is about half as long as the entire ramus. Habitat: The only specimens yet found in America were found in a small spring-fed water tank on Clark University campus, Atlanta, Georgia, Aug. 30, 1894.

Candona acuminata (Fischer)

PLATE LXXI, FIG. 34.

1851.—*Cypris acuminata* S. Fischer (64), p. 148; Pl. IV, Figs. 12-16.
1854.— " " Zenker (238), p. 74; Pl. II, D.
1889.— " " Brady and Norman (31), p. 104; Pl. IX, Figs. 9-10; Pl. X, Figs. 5-6.
1894.— " " C. H. Turner (215), p. 19; Pl. VIII, Fig. 34.

Length 1.25 mm. Height 0.58 mm. Width 0.46 mm.

The shell is smooth, white, and elongated. It is more than twice as long as high and about three times as wide.

Viewed from the side, the shell is sub-reniform, highest in the middle.

Viewed from above, the shell is sub elliptical with pointed extremities. The widest portion is in the middle. One valve is a trifle longer than the other.

The antennæ are stout. The natatory setæ are absent and the terminal is long and non-pectinated.

The post-abdomen (Fig. 34) is curved and slender. The terminal claws are slender and pectinated.

Habitat: San Antonio River, Texas. I have seen only three specimens of this species. They were collected for me by Mr. A. B. Whitby.

Candona crogmani Turner.

PLATES LXXI, FIGS. 24-33; LXXXI, FIGS. 4-5.

Candona crogmaniana—C. H. Turner (215), p. 20; Pl. VIII, Figs. 24-33.

Length of female 1.52 mm. Height 0.76 mm. Width 0.58 mm.

This form is about the size of the elongated variety of *Candona candida*. The two most obvious differences are: 1, the inequivalve shell with pointed extremities; 2, the second foot is six-jointed.

The shell is very thin, so thin that the ova and spermatozoids are visible through it. It is glossy and is covered with short scattered hairs. These hairs are more numerous around the margins than elsewhere. In the living specimen the body shines through the pellucid shell and gives it a greenish yellow tint. Numerous *Vorticellidæ* are usually found attached to the lorica.

Viewed from the side (Fig. 33), the female is sub-triangular, the caudal third being the highest portion. The caudal, dorsal and cephalic margins are convex. The ventral margin is slightly sinuate, being concave in the middle.

Viewed from above (Fig. 32), the shell is an elongated ellipse, pointed at both ends. One valve is longer than the other and overlaps it at each extremity.

The antenna (Fig. 25) is five-pointed in the female. Near the proximal end of the lower margin of the first joint there is one elongated filament and one short, pectinated, dagger shaped filament. The terminal claws are slender, non-pectinated and long—longer than the combined lengths of the last three joints. The antenna of the male is six-jointed.

The mandibular palp (Fig. 31) is five-jointed. The first joint is large and bears at the distal angle of its inner margin a short dagger-like seta (Fig. 31). The distal half of this seta is pectinate. The mandibular blade is stout.

The spines of the first mandibular process of the first maxillæ are non-pectinated.

The first foot (Fig. 29) is long and slender and is composed of five joints. The second joint is about as long as the next two joints. The third and fourth joints are of about the same length. The fifth joint is the smallest of all. It is conical and from its distally directed apex arises the terminal claw. The terminal claw is slender and long. It is longer than the combined lengths of the last three joints and the distal portion is flexuose.

The fourth joint of the second foot (Fig. 30) is somewhat obscurely divided into two joints, so that the second foot appears, under a high power, to be composed of six joints. The foot terminates in two long flexuose filaments and one shorter filament.

The post-abdomen (Fig. 28) is of medium size. The terminal claws are slender, pectinated and curved. The terminal claw is about half as long as the abdominal ramus. The adjacent claw is a little shorter than the terminal claw. The filament in the caudal margin is about one-third the length of the ramus from the distal extremity of the post-abdomen.

Habitat: Atlanta, Georgia, December, 1893. Abundant in the shallow ponds near South River. The ponds in which these specimens were found dry up in warm weather.

Candona Peircei sp. n.

PLATE LXXX.

Length 0.70 to 0.79 mm. Height 0.33 to 0.37 mm. Width 0.22 to 0.31 mm.

The color of the shell is white tinged with yellow. The surface is highly polished and bears a few scattered hairs. The muscle impressions are sub central and the eye is not visible through the shell. The animal is about half as high as long, but is not quite so wide as high.

Viewed from the side the shell is sub-reniform, the greatest width being a little caudad of the middle. The two extremities are rounded and are of about the same width. The dorsal margin is feebly convex, in some specimens it is nearly flat. The ventral margin is somewhat sinuous, the middle being slightly concave. In some specimens this margin is almost straight.

Viewed from above, the shell is sub-elliptical with pointed extremities. The cephalic extremity is more sharply pointed than the caudal. The sides are convex. The hinge-line throughout the greater part of its course is straight, but near the cephalic extremity of the valve there is a slight sinuosity. Viewed from below the shell has the same general appearance as when viewed from above. The contact line is quite sinuous.

The antenna of the female is five jointed. Near the distal extremity of the inner margin of the second joint there is a long seta, which extends about to the base of the fifth joint. Near the proximal extremity of the inner margin of the third joint there is the usual biarticulate olfactory hair. Near the proximal extremity of the outer margin of the same joint arises a long seta which extends almost to the base of the next joint. From the distal extremity of the inner margin of this joint there arise one long and one short seta. The long seta reaches way beyond the tip of the fifth joint, while the short one does not reach to the extremity of the fourth joint. From the middle of the inner margin of the fourth joint there arise one long and one short seta. The long seta extends to beyond the tip of the terminal joint while the other extends to a little beyond the base of the same joint. From the middle of the outer margin of the fourth joint there arises a short seta which extends to about the base of the next joint. The tip of the fourth joint bears two long and one short claw. The two long claws are stout and are longer than the combined lengths of the last two joints. The short claw is only about twice as long as the terminal joint. From the tip of the fifth joint there arise one long and one shorter claw. The shorter claw is about two-thirds as long as the other claw. The tip of this joint bears also a biarticulate sensory filament.

The antenna of the male is six-jointed. In structure and appendages the first three joints resemble the corresponding portion of the female antenna. From the distal extremity of the fourth joint arise two peculiar biarticulate sensory filaments which extend to beyond the tip of the terminal joint. From the distal extremity of the outer margin of this same joint arises a short seta which extends to about the tip of the fifth joint. From the distal extremity of the fifth joint arise two long curved claws and one medium seta. The claws, which are of equal length, are longer than the combined lengths of the last three joints. The claws arise from the outer portion, while the seta springs from the inner angle of the margin. The seta is about one-half as long as one of the claws. From the distal extremity of the sixth joint there arise one long terminal claw and one biarticulate sensory seta. The claw extends to the tips of the claws that spring from the fifth joint, but the seta extends less than half so far.

The palp of the mandible is stout, the terminal joint of the same is short. The blade of the female mandible is stouter than that of the male.

The first maxilla bears a large leaf-like branchial appendage.

The second maxilla of the female has the usual generic form, the palp being two-jointed and bearing at its tip three short setæ. In the male the palp of the second maxilla is peculiarly modified and the palp of one side is larger than the palp of the other.

The first foot is of the usual type.

The second foot, as is always the case in this genus, bears at its tip two long and one short setæ.

The post-abdomen of the female is quite stout and bears at its tip two strong claws. This appendage is strongly curved. One claw is only about two-thirds as long as the other.

The post-abdomen of the male is straighter than that of the female, but its borders are more irregular. The terminal claws are slender and of about the same size.

The verticillate sac of the male bears seven whorls of chitinous spines.

Habitat: Fayette county, Georgia. These specimens were found in the weedy shallows of a large millpond near Fayetteville, June 21, 1894.

Candona delawarensis Turner.

PLATE LXXI, FIGS. 35-40.

1894.—*Candona delawarensis* C. H. Turner (215), pp. 21-22; Pl. VIII, Figs. 35-40.

Length 0.95 mm. Height 0.54 mm. Width 0.43 mm.

The color of this form is greenish yellow variegated with blotches of brown.

Viewed from the side (Fig. 39) the shell of the female is sub-reniform, the greatest height being about two-thirds the length of the animal from the cephalic extremity of the shell. The cephalic, dorsal and caudal margins are convex. The ventral margin is undulating, concave in the middle.

Viewed from above (Fig. 37) the shell is an elongate ellipse with its greatest width in the middle. The extremities are pointed. The hinge-line is sinuous. Near the cephalic extremity there is a very pronounced sinuosity.

Viewed from below (Fig. 38) the general outline is the same as when viewed from above. The contact line is more sinuous than the hinge-line.

Viewed from the end the shell is elliptical. It is widest in the middle and the extremities are rounded.

The antennæ bear no natatory setæ on the antepenultimate joint. The terminal claws are non-pectinated and long. They are about as long as the combined lengths of the last three joints. The lower margin of the antepenultimate joint bears a modified sensory seta. The antenna of the male is six-jointed. The mandibular palp of the female is large. The antepenultimate joint bears, in addition to the usual long sensory setæ, one short and stout sensory seta which is sub-rectangular in form with truncated ends and convex sides. It is about four times as long as wide.

The spines on the first mandibular process of the first maxilla are not toothed.

The post-abdomen of the male (Fig. 36) is slender and sub-triangular. The terminal claws are slender and curved.

Habitat: Jones' Creek, Kent County, Delaware. The specimens that I have were collected by Mr. L. D. Hileland, March 3, 1894.

GENUS CYPRIA Zenker. 1854.

This genus, which was founded by Zenker (238), has been revised by Wenzel Vávra (221).

Antennules are seven-jointed.

Antennæ in the female are five-jointed; in the male they are six-jointed. The distal extremity of the fourth joint bears two olfactory setæ. The natatory setæ on the third joint are very long, extending way beyond the tip of the terminal claws.

The mandibular palp is much elongated; this is especially true of the terminal joint.

The palp of the first maxilla is strongly developed.

The second maxilla bears a well-developed branchial plate. In the female the palp of this member is unjointed and terminates with three setæ. In the male the palp of the second maxilla forms a hooked prehensile organ. In that case the left palp differs somewhat in size and configuration from the right.

The small terminal joint of the second foot, which is about one-third as long as the fourth joint, bears two equally long backwardly directed setæ.

The abdominal rami are robust; the caudal seta is situated about midway the caudal border.

The eye is large. Muscle impressions four.

Males are numerous. The central cylinder of Zenker's organ is surrounded by seven whorls of chitinous setæ. The upper part of the organ forms a blind dilated sac; the lower forms the funnel-shaped origin of the vas deferens. The copulative organ is triangular.

The species of this genus are all small ovate or reniform creatures.

Cypria exculpta S. Fischer.

PLATES LXX, FIGS. 1-8; LXXII, FIG. 3.

1853.—*Cypris elegantula* Lilljeborg (118), p. 206.
1854.— " *exculpta* Fischer (65), p. 18; Pl. XIX, Figs. 36-38.
1854.— " *punctata* Fischer (65), p. 77; Pl. III, Figs. 1-6.
1864.— " *striolata* Brady (11), p. 60; Pl. III, Figs. 12-17.
1868.— " *striolata* Brady (18), p. 372; Pl. XXIV, Figs. 6-10.
1880.— " *granulata* Robertson (184), p. 18.
1887.— " *striolata* C. L. Herrick (86), p. 29; Pl. IV, Fig 3.
1889.—*Cypria exculpta* Brady and Norman (31), pp. 68-69; Pl. XI, Figs. 1-4.
1894.— " *exculpta* C. H. Turner (215), p. 13; Pl. VII, Figs. 2-8.
1894.— " *exculpta* C. H. Turner (216), p. —.

Length of female 0.54 to 0.64 mm. Height 0.33 to 0.43 mm. Width 0.26 mm.

The shell is thin and somewhat transparent and is covered with a meshwork of sub longitudinal lines (Fig. 5).

Viewed from the side (Fig. 3), the shell is orbicular, highest in the middle, the two extremities being of about equal height. The cephalic, dorsal and caudal margins are convex. The ventral margin is slightly sinuate, being concave in the middle.

Viewed from above the shell is an elongated, laterally-compressed ellipse. The two extremities are of about the same width and the line of contact is straight.

The natatory setæ of the antennæ (Fig. 6) extend far beyond the terminal claws and are much longer than the entire limb. The claws on the tip of each antenna are long and slender. They are longer than the last three joints.

In the male the second maxillæ (Fig.8) are dissimilar.

The tip of the second foot (Fig. 2) bears two short ectally projecting setæ and two long setæ which project backwards as far as the base of the antepenultimate joint.

The post-abdomen (Fig. 7) is short, stout and curved. The terminal claw is strong and about half as long as the ramus. About the middle of the caudal margin of each abdominal ramus there is a short filamentous seta.

Habitat: This species is quite abundant in shallow ponds and slowly flowing shallow creeks.

In America this species has been found at: Atlanta, Georgia (Turner, 215); Burlington, Ohio (Turner, 215); Alabama (Herrick, 86); Kent County, Delaware (Turner, 215); Fayette County, Georgia (Turner). The specimens from Delaware were collected for me by Mr. L. D. Hileland.

Cypria opthalmica Jurine.

PLATES LXXV, FIGS. 1-3, 7; LXXVI, FIGS. 1-3, 5.

1820.—*Monoculus opthalmicus* Jurine (98), p. 178; Pl. XIX, Figs. 16, 17.
1835.—*Cypris compressa* Baird (1), p. 100; Pl. III, Fig. 16.
1837.— " *punctata* Koch (102), H. 21, p. 23, Fig. 23.
1837.— " *tenera* Koch (102), H. 12, p. 3.
1850.— " *compressa* Baird (5), p. 154; Taf. XIX, Figs. 14, 14a-c.
1851.— " *elegantula* Fischer (63), p. 161; Pl. X, Figs. 12-14.
1853.— " *compressa* Lilljeborg (118), p. 112; Pl. X, Figs. 16-18.
1854.—*Cypria punctata* Zenker (238), p. 77; Taf. III, A.
1868.—*Cypris compressa* Brady (18), p. 372; Pl. XXIV, Figs. 1-5; Pl. XXXVI, Fig. 6.
1868.— " *ovum* Fric u. Nekut (70), p. 48, Fig. 30.
1872.— " *ovum* Fric (69), p. 213, Fig. 28.
1875.— " *compressa* Brady, Crosskey, and Robertson (30), p. 123; Pl. I, Figs. 5, 6.
1879.—? *Cypria neglecta* Herrick (83), p. 112; Pl. XVII, Fig. 2.
1885.—*Cypris punctata* Nordquist, (155) p. 150.
1888.— " *punctata* Schwarz (199), p. 18.
1888.— " *compressa* Sostaric (202), p. 47.
1889.—*Cypria opthalmica* Brady and Norman (31), p. 69; Pl. XI, Figs. 5-9.
1891.— " *opthalmica* Wenzel Vávra (221), pp. 63-66; Figs. 19, 19^1-19^6, 20, 20^1-20^4.

Length 0.55 to 0.58 mm. Height 0.37 to 0.40 mm. Width about 0.30 mm.

The American representative appears to be somewhat wider than the European type.

The translucent shell is covered with irregularly scattered large puncta. Near the two extremities, the shell bears long hairs.

Viewed from the side the shell is reniform, widest back of the middle. Near the two extremities, the dark puncta are often so clustered as to form dark blotches. Caudal, dorsal and cephalic margins convex. Ventral margin is somewhat sinuate.

Viewed from above the shell is ovate, the cephalic end somewhat more narrow and more pointed than the caudal extremity. Hinge line is straight.

Viewed from below the contact line is sinuate.

Viewed from the end the shape is oval, much higher than wide.

For the structure of the female antenna consult Fig. 1.

For the structure of the mandible consult Fig. 5.

For the structure of the second foot consult Fig. 2.

For the structure of the abdominal ramus consult Fig. 3.

Habitat: ? Minnesota (Herrick, 83); Baxley, Georgia. The specimens from Baxley were collected for me by Mr. A. B. Whitby. The figures were drawn from Baxley specimens.

Cypria mons (Chambers).

PLATE LXXXI, FIGS. 6-12.

?.—*Cypris mons* Chambers (41), pp. 153-154, Fig. 3.
1887.— " *mons* C. L. Herrick (86), p. 32.

Length 0.70 mm. Height 0.45 mm.

"Ovoid; tumid; highest immediately before the middle. Length $\frac{1}{36}$ inch; height $\frac{1}{57}$. Dorsal margin regularly arched, sloping more rapidly behind the highest point than before it. Extremities rounded; the anterior widest ventral margin very slightly sinuated. Seen from above, ovate, but less tumid than *Cypridopsis vidua* as figured by Baird and Brady (Brit. Ent. and Trans. Linn. Soc.). But little or not at all narrowed in front; widest a little behind the middle. Lucid spots seven, near the middle of the valve; the three lower ones in a line and small; one of them very small. Valves white, shining smooth, with numerous almost confluent puncta. The setæ of the lower antennæ extend beyond the apex of the claws, and the articulate appendage of the third joint has its apex swollen or enlarged. Superior antennæ with two long and one short seta from the end of the fourth joint; two from the end of the fifth joint; four long ones from the end of the sixth; two long and two short from the end of the seventh (there are also other short setæ on the different joints). The last joint of the inferior antennæ is small, almost rudimentary, bearing a single large claw. (Indeed, it seems to be bifid, with a claw from each branch.) There are three other claws articulated to the end of the penultimate joint, from which also arise four setæ shorter than the claws; two moderately long setæ arise from about the middle of the fourth joint above, and three longer ones below: the usual fasciele of five long and one short setæ from the third joint, just behind which is a bunch of short cilia and another bunch on the under side. Abdominal ramus straight, slender, with two claws, one under the other. The mandibular palpus, with branchial appendage and two large plumose and one simple setæ from the end." (Chambers.)

I have never seen specimens of the above. It is certainly very closely related to *Cypria opthalmica* (Jurine), yet it seems to be distinct.

Habitat: Pond on Mount Elbert, Colorado; altitude 11,000 feet. (Chambers, 41.)

Cypria inequivalva Turner.

PLATE LXVIII, FIGS. 1-8.

1893.—*Cypria inequivalva* C. H. Turner (213), pp. 6-8; Pl. I, Figs. 1-8.
1894.— " *inequivalva* C. H. Turner (215), p. 14.
1894.— " *inequivalva* C. H. Turner (216).

Length 0.46 mm. to 0.52 mm. Height 0.35 mm. to 0.36 mm. Width 0.26 mm.

Shell inequivalve, one valve overlapping the other in front. Valves glossy, finely pubescent.

In fresh specimens, near the cephalic end of the shell, there is an irregular cross-shaped dorsal dark spot (Figs. 1, 2), the arms of which extend latero-ventrad along each valve for about one-half the height of the valve. Near the caudal extremity of the shell there is another irregular dorsal dark spot. This spot is somewhat fan-shaped, with the expanded portion directed caudad. Occasionally, on the ventral surface, about one-third the length of the valve from the cephalic extremity, a small dark spot is seen. In fresh specimens these markings are very pronounced; but in alcoholic specimens, they are usually more or less obscured.

Viewed from the side (Fig. 1) the shell is sub-reniform, higher near the middle. It is about twice as long as high. Dorsal margin, feebly convex; cephalic margin, convex; ventral margin, nearly straight, slightly concave in the middle; caudal margin convex.

Viewed from above (Fig. 2) the shell is sub-elliptical, inequivalve, one valve overlapping the other in front. Shell widest near the middle. Cephalic extremity about as wide as the caudal. All margins convex. Hinge-line straight.

Viewed from below (Fig. 3) shell presents the same outline as when viewed from above, but the line of contact of the two valves is sinuated.

Viewed from the end, the shell is oval, widest in the middle, ventral margin about as wide as dorsal.

Antennules typical for the genus.

Antennæ of female (Fig. 4) composed of five joints, the joints diminishing in size from the second to the most distal joint. The second joint bearing at about the middle of its ental margin a long seta. The next joint bears at about the middle of its ental margin the usual biarticular sensory hair and at its disto-ental angle a moderately long plumose seta, this seta extends to about the base of the terminal claws. From the base of the penultimate joint arise five very long non-plumose setæ, these setæ extending far beyond the tips of the terminal claws. At the middle of its ental border this joint bears a short seta, and opposite this on the ectal border there is a slightly longer seta. From the disto-ental angle of this joint arise two short setæ. From the ectal half of its distal margin arise two long claws; one of these claws extends beyond the tip of the claws springing from the terminal joint, while the other extends nearly to the tip of those claws. At the extremity of the terminal joint there are two large

claws and two short setæ; one of these setæ is located at the disto-ental angle and the other at the disto-ectal angle of the joint. The claws are smooth.

In the male the antenna is six-jointed, and the terminal claws are longer and more flexible than in the female.

Mandible resembles that of *Cypria exculpta* Fischer.

First foot of female (Fig. 5) long and slender, composed of five joints. The most proximal joint large, the broadest of all. The next joint the shortest of all. The antepenultimate joint about as long as the most proximal, but more slender. From the margin of this joint arise two short setæ. From the disto-caudal angle of this joint arises a long seta which extends to beyond the base of the terminal claws. From near the disto-cephalic angle of this joint arises a short seta. Along the cephalic margin of the penultimate joint there is a longitudinal row of fine hairs. From the disto-caudal angle of this joint arises a seta of medium length. From the extremity of the terminal joint arises a long claw; this claw is much longer than the joint and appears to be composed of two portions; a short proximal and a long distal portion. From the cephalic margin of the proximal portion arises a short seta.

Second foot of female (Fig. 6) composed of five joints, the joints diminishing in size from the second to the most distal joint. The most proximal joint bears at about its proximo-caudal angle a long plumose seta which is as long as the joint; and from the distal third of its cephalad margin arises a somewhat shorter seta. From the distal fourth of the cephalic margin of the antepenultimate joint arises a seta. From a corresponding point on the penultimate joint there also arises a seta. From the extremity of the terminal joint arise two long and two short setæ. The two long setæ are about as long as the entire limb.

The two shorter setæ are but little longer than the terminal joint.

Post-abdomen (Fig. 7) is curved, bearing one terminal claw and at its base a short terminal spine. On the convex surface there is a subterminal claw.

Verticillate sac (Fig. 8) of male as usual in this genus. It seems to be enclosed by a transparent capsule.

Habitat: This species is abundant among the grass and weeds of many shallow ponds. It has been found at the following places: Cincinnati, Ohio (Turner, 213); Atlanta, Georgia (Turner, 215); Fayette County, Georgia (Turner, 216).

GENUS CYCLOCYPRIS Brady & Norman. 1889.

This genus, founded by Brady and Norman (31), has been amended by Wenzel Vávra (221).

Antennules are seven-jointed.

The antennæ of the female are five-jointed; of the male, six-jointed. There is no olfactory organ on the fourth joint. Natatory setæ are very long, reaching far beyond the tip of the terminal claws. The palp of the mandible and of the first maxilla normally developed.

The second maxilla bears a branchial plate and a palp. In the female this palp is unjointed; in the male it forms a hooked prehensile organ.

The last joint of the second foot is unusually long, being two-thirds as long as the fourth joint.

Males are numerous. Zenker's organ is similar to that of *Cypria*. The proximal side of its central cylinder is flat. Vas deferens is long and convoluted. The copulative organ is quadrangular.

The abdominal ramus is robust, the caudal seta is situated at about one-third the length of the caudal border of the ramus from its distal extremity.

Cyclocypris laevis (O. F. Müller.)

PLATE LXX, FIGS. 9-11.

1785.—*Cypris laevis* Müller (149), p. 52; Pl. III, Figs. 7-9.
1820.—*Monoculus ovum* Jurine (98), p. 179; Pl. XIX, Figs. 18, 19.
1835.—*Cypris minuta* Baird (1), pp. 99; Pl. III, Fig. 9.
1837.— " *brunnea* Koch (102), H. X., Fig. 5.
1837.— " *lepidula* Koch (102), H. X. 6.
1850.— " *minuta* Baird (5), p. 155; Pl. XVIII, Figs. 7 and 8.
1851.— " *pantherina* Fischer (64), p. 163; Pl. XI, Figs. 6-8.
1853.— " *ovum* Lilljeborg (118), p. 113; Pl. X, Figs. 13-15.
1868.— " *ovum* Brady (18), p. 373; Pl. XXIV, Figs. 31-34, 43-45; Pl. XXXVI, Fig. 8.
1868.— " *ovum* Claus (48), Pl. I, Figs. 1-5.
1874.— " *ovum* Brady, Crosskey & Robertson, (30), p. 125; Pl. I, Figs. 29, 31.
1888.— " *ovum* Schwarz (199), p. 18.
1888.— " *ovum* Sostaric (202), p. 46.
1889.—*Cypria laevis* Brady and Norman (31), p. 69.
1891.— " *laevis* Wenzel Vavra (221), pp. 68-71, Figs. 21, 21^{1}-21^{6}.
1894.— " *laevis* C. H. Turner (215), pp. 14, 15; Pl. VII, Figs. 9-11.
1894.— " *laevis* C. H. Turner (216).

Length 0.51 mm. to 0.57 mm. Width about 0.4 mm.

The somewhat translucent shell is hispid and very tumid, being about as broad as it is high.

Viewed from above the shell is ovate with rounded extremities. The eye, which is situated near the cephalic extremity of the animal, is easily seen through the shell.

The five large setæ on the antepenultimate joint of the antennæ extend way beyond the tip of the terminal claws (Fig. 9). The distal extremity of each seta is plumose. According to Professor Brady* in *Cypris ovum* (Jurine) only two of the natatory setæ of each antenna are long. In this respect *Cypris ovum* (Jurine) differs from the specimen under consideration; but since they are similar in all other features I consider them to be of the same species.

The terminal joint of the mandibular palp is short. The terminal claws of this palp extend to the tip of the mandibular teeth.

The slightly curved terminal claw of the first foot is slender and is about as long as the combined lengths of the three distal joints.

The terminal joint of the second foot is about two-thirds as long as the fourth joint (Fig. 11). The long, slender, backwardly directed seta upon the distal extremity of this joint is longer than the combined lengths of the three distal joints. This joint bears at its apex two other setæ; one, about the same length as the joint is directed backward, the other is very short and is directed forward.

The short post-abdomen is about twice as long as its terminal claws. The stout claws are feebly curved.

Habitat: I have seen only three specimens of this species. These Professor L. D. Hileland collected in Jones' Creek, Kent County, Delaware, March 31, 1894.

Cyclocypris modesta (Herrick.)

PLATE LXXII, FIGS. 5, 5*, 5a, ETC.

Cypris modesta C. L. Herrick (86), p. 28; Pl. IV, Fig. 5.

This species has never been seen by me. Probably its nearest ally is *Cypria inequivalva* Turner. The figures as well as the text of this species are taken from Professor Herrick's work (86).

"Shell sub-reniform, greatest height behind the middle, upper outline somewhat obliquely truncate, especially in the male; color yellowish, scarcely maculate, nearly smooth. Antennæ short, with long non-plumose filaments, two from the apical and four from the penultimate segment very long, others half as long; second antennæ with three toothed claws on the penult segment, one together with three smaller ones, on the apical, antepenult segment armed only with small bristles, preceding one with six long setæ exceeding the claws; first foot slender, apical segment long conical, with a long serrate claw and bristle, other setæ short; second foot (in male) with a short terminal segment armed with two very long setæ and one shorter one; caudal stylets very slender, with a terminal claw, a sub-terminal claw some-

* Recent British Ostracoda, p. 373.

what smaller and a weak pectinate seta one-fifth the length of the stylet from the end; palp of mandible very bristly. The intromittant organ of the male is more simple than those hitherto described, consisting of a broad, flat basal segment on either side, with a coiled ductus ejaculatorius and a funnel-shaped terminal portion consisting of two opposable flaps. The basal segment is indistinctly two jointed and those of both sides are seated on a common prominence.

"Length of male 1.70 mm., of female 2.16 mm.; height of male 0.84 mm., of female 1.24 mm. The above measurements are too large, but express the correct proportions. It is one of the smaller species."

Habitat: ? Alabama (Herrick, 86).

GENUS CYPRIDOPSIS Brady. 1868.

The antennule is seven-jointed.

The antenna is five-jointed. The five natatory setæ on the third joint are plumose.

The branchia of the second maxilla consists either of a plate bearing five plumose setæ or else of two setæ which are inserted directly on the blade.

The second foot is five-jointed and bears, near its extremity, a strong chitinous claw.

The abdominal rami are rudimentary.

The members of this species seem to be exclusively parthenogenetic.

Cypridopsis vidua (O. F. Müller.)

PLATES LXXII, FIGS. 1-1g; LXXV, FIGS. 5, 6, 8, 9; LXXVI, FIGS. 4, 7.

1785.—*Cypris vidua* O. F. Müller (149), p. 55; Taf. IV, Figs. 7-9.
1820.—*Monoculus vidua* Jurine (98), p. 175; Pl. XIX, Figs. 5-6.
1837.—*Cypris maculata* Koch (102), H. 10, 2.
1841.— " *strigata* Koch (102), H. 36, 19.
1844.— " *vidua* Zaddach (234), p. 35.
1850.— " *vidua* Baird (5), p. 152; Pl. XIX, Figs. 10-11.
1850.— " *sella* Baird (5), p. 158; Pl. XIX, Figs. 5, 5a.
1851.— " *vidua* Fischer (64), p. 162; Taf. XI, Figs. 1-2.
1853.— " *vidua* Lilljeborg (118), p. 111.
1854.— " *vidua* Zenker (238), p. 79.
1868.—*Cypridopsis vidua* Brady (18), p. 375; Pl. XXIV, Figs. 27-36, 46.
1868.—*Cypris vidua* Claus (48), Pl. I, Figs. 6-8.
1868.— " *vidua* Fric and Nekut (70), p. 48, Fig. 29.
1869.—*Cypridopsis obesa* Brady and Robertson (32), p. 364; Pl. XVIII, Figs. 5-7.
1870.— " *obesa* Brady and Robertson (33), p. 15.
1870.—*Cypris vidua* Heller (81), p. 90.
1872.— " *vidua* Fric (69), 227.
1874.—*Cypridopsis obesa* Brady, Crosskey and Robertson (30), p. 128; Pl. I, Figs. 1-4.
1879.—*Cypris vidua* C. L. Herrick (83), p. 112; Pl. XVII, Fig. 1.

1887.—*Cypridopsis vidua* C. L. Herrick (86), p. 33; Pl. IV, Fig. 1.
1888.—*Cypris vidua* Sostaric (202), p. 46.
1889.—*Cypridopsis vidua* Brady and Norman (31), p. 89.
1891.— " *vidua* Wenzel Vávra (221), pp. 75-77; Figs. 23, 23^1-23^4.
1892.— " *vidua* C. H. Turner (212), p. 73.
1894.— " *vidua* C. H. Turner (215), p. 19.
1894.— " *vidua* C. H. Turner (216).

Length 0.54 mm. to 0.7 mm. Height 0.34 mm. Width 0.37 mm. to 0.49 mm.

The color of the tumid shell is yellowish green. The shell is covered with short sparse hairs and is marked with three characteristic dark bands (Pl. LXXV, Figs. 5, 8). These bands are confined to the dorsal surface.

Viewed from the side (Pl. LXXV, Fig. 5) the shell is sub-reniform in outline, widest in the middle. Excepting a slight concavity at the middle, the ventral margin is straight. The other margins are strongly convex. Muscle impressions sub central.

Viewed from above (Pl. LXXV, Fig. 8) the shell is broadly ovid, being widest caudad of the middle. The two extremities are rounded, but the cephalic extremity is much more narrow than the other. The sides are strongly convex and the hinge-line is straight.

Viewed from below (Pl. LXXV, Fig. 6) the shell has the same general shape as when viewed from above. The contact line is sinuous and there is a slight depression in the centre.

Viewed from the cephalic end (Pl. LXXV, Fig. 9) the shell is a broad oval, being wider than high. Contact line straight.

The antenna is five-jointed (Pl. LXXVI, Fig. 7). The terminal joint is small. A projection from the outer angle of the distal extremity of the penultimate joint extends half way the length of the terminal joint. Two of the terminal claws are stout and one of them bears, on its inne margin, blunt teeth. The natatory setæ extend to a little beyond the tip of the terminal claws and are plumose.

The mandible is stout. The claws of the mandibular palp extend to the tips of the mandibular teeth. The antepenultimate joint of the palp bears a short, pectinated, dagger-shaped seta. As far as my observations go, the penultimate joint does not bear such a seta. The fact that the dagger-shaped seta found on the penultimate joint of some *Cyprida* occurs on the side renders its detection quite difficult.

The abdominal rami (Pl. LXXVI, Fig. 4) are rudimentary, the long slender terminal claw being longer than the ramus. In addition to the terminal claw there is a shorter and more slender claw.

Habitat: This species occurs in all kind of fresh water. I have found it in small tanks, pools, ponds, lakes, creeks and small rivers. It usually occurs in great numbers.

In America it has been found in the following localities: Eastern United States (Herrick, 86), Georgia (Turner, 215, 216), Ohio (Turner, 212, 213), Texas (Turner 215, 216), Minnesota (Herrick, 83), West Virginia (Turner, 215).

The Texas specimens were collected by Mr. A. B. Whitby.

Cypridopsis newtoni Brady and Robertson.

PLATE LXXII. FIG. 6-6h.

1870.—*Cypridopsis* (?) *newtoni* Brady and Robertson (33), p. 14, Pl. VII, Figs. 14-16.
1874.— " *newtoni* Brady, Crosskey and Robertson (30), p. 129; Pl. II, Figs. 20-21.
1887.— " *hystrix* C. L. Herrick (86), pp. 30, 31; Pl. IV, Fig. 6.
1889.— " (?) *newtoni* Brady and Norman (31), pp. 90, 91; Pl. VIII, Figs. 16, 17.
1891.— " *newtoni* Wenzel Vavra (221), pp. 77-79; Figs. 24, 24^1-24^5.
1894.— " C. H. Turner (216).

Not having met this species, I here give Professor Herrick's description. The figures are his also.

"Length equal to about twice the greatest height which lies just behind the anterior third, anterior outline much higher than the posterior, and evenly rounded, posterior margin acutely angular, lower outline slightly concave, upper margin twice angled; shell covered with long curved spines; color yellowish, with eight lucid spots. Antennæ (first antennæ) slender, composed of seven segments, of which all but the basal are short and sub-equal. * * * * * Antennules (second antennæ) with very short apical segment with two strong unequal claws and a minute seta, penultimate with two equal toothed claws and a number of slender setæ, third from end with five long and several short setæ, preceding segment large, with three slender setæ. First foot five-jointed, second joint elongated, third and fourth equal, each with a single short seta, apical segment small, with two setæ and a long toothed gently curved claw; last foot moderately slender, terminal joint with a small claw and two setæ at the apex and a lateral spine. Caudal stylets reduced to minute papillæ bearing a slender claw and a flexuous spine. The mouth parts bear the characters of the genus *Cypris*.

"In this species there is an aureole-like lucid zone about the anterior of the shell and a similar, but triangular, appendage behind.

"The species may be regarded as forming a transition to *Cypris* proper, as the form if not the size of the stylets is more as in that genus."

Habitat: Minnesota (Herrick, 86).

GENUS ERPETOCYPRIS Brady and Norman. 1889.

"General characters of the animal closely approaching those of *Cypris;* but the setæ of the third joint of the lower antennæ are short, not nearly reaching the apex of the terminal claws, and are not plumose. The second pair of jaws have branchial plates as in *Cypris.* The power of swimming is lost, and the habits of the animals, which creep along the bottom, are thus very different from those of *Cypris.*" (Brady and Norman).

Erpetocypris minnesotensis (Herrick.)

PLATE LXXII, FIGS. 2-2h.

1887.—*Cypris minnesotensis* C. L. Herrick (86), p. 28; Pl. IV, Fig. 2.

Length 1.60 mm.

This species is closely related to *Erpetocypris fasciata* (O. F. Müller). In *E. fasciata* the caudal margin of the abdominal ramus is smooth, but in *E. minnesotensis* it is pectinate. In *E. fasciata* the length is three times the width, but in *E. minnesotensis* the length is two and one-half times the width.

The figures and the following description are from Professor Herrick (86).

"From any of the American species it is at once known by the great proportionate length of the valves, which are about two and one-half times as long as broad. Lower margin nearly straight, gently sinuous near the middle, dorsal margin gently curved, highest back of the middle, then gently curved; color light, with two inconspicuous dark transverse bands on either side at about the anterior and posterior thirds; scattered hairs upon prominences are found near the margins. Antennæ (antennules) slender, seven-jointed, apex with two very long and one short spine, penult segment with four long setæ, antepenult segment with two long plumose setæ above, preceding segment with shorter setæ; second antennæ with the apical segment very short and armed with one (?) serrate claw and a seta, the preceding with two claws and a few short setæ, antepenult segment with three (four?) shortish setæ, not reaching end of claws; mandible with strong lobed teeth and a large palp; first foot with a large claw; second foot slender, ending in a small hook with a single weak seta; caudal stylets rather short and wide, with two strongly serrated claws, the other spines being obsolescent (?); posterior margin serrulated. Lucid spots of the shell seven in number, two being minute. Length of shell 1.6 mm."

Habitat: Minnesota (Herrick, 86).

Erpetocypris barbatus (Forbes.)

PLATE LXXVII.

1879.—*Candona ornata* (?) C. L. Herrick (83), p. 113; Pl. XX, Fig. 1.
1893.—*Cypris barbatus* S. A. Forbes (67a), pp. 244-246; Pl. XXXVII, Figs. 2 3; Pl. XXXVIII.

This, which is probably the largest freshwater ostracode, is known to me only through the paper of Professor S. A. Forbes. The following description, as well as the figures, is copied from his paper.

"An extremely large, very hairy, oblong *Cypris*, with rounded ends and dorsal and ventral margins nearly parallel. Length 4.0 mm. Width 1.6 mm. Depth 2.0 mm. A very little deepest at hind end of hinge margin. (Depth across eye 95 per cent of greatest depth.)

"Dorsal margin about straight for a great part of its length, the ventral margin very slightly emarginate or sinuate at its anterior third. The anterior end broadly and smoothly rounded, more obliquely above than below, the posterior somewhat obliquely rounded, the ventral margin being thus nearly half as long again as the dorsal. Seen from above the shape is symmetrical, a slender oval, a little more flattened at the sides behind than before; thickest, consequently, before the middle.

"Color a dirty yellowish brown in alcohol, with a reddish-brown patch on either side above and behind the middle. Surface of valves opaque, very minutely roughened, and well covered with conspicuous hairs, which give this *Cypris* [*Erpetocypris*] a decidedly hairy appearance to the naked eye. Hairs longest before and behind and lengthening generally towards the margin, where they project as a fringe, the most prominent part of which is a row of hairs borne on slender conical tubercles within the margin of the valves. The valves are equal and the shell fairly full, but not plump.

"Anterior antenna with the basal segment obliquely channeled, partially dividing it into two, the distal part of which bears a single bristle on its superior surface, and two long, more slender ones, springing together from tip of the ventral surface. A short, subquadrate second segment bears a single seta, about as long as the segment, on the dorsal surface, near the tip. From the distal end of the following segment spring two long, slightly plumose setæ, one dorsal, one ventral, the former much the longer. The fourth segment bears at its tip four long setæ, two of which arise from the ventral angle and two from the outer dorsal. The following segment is similarly armed, and the distal extremities of the sixth and seventh are densely set with long plumose setæ forming a stout fascicle, which extends beyond the end of the antenna a distance equal to the length of the antenna itself.

"The terminal segment of the palp of the first maxilla is a little more than a fourth the length of the basal, the latter with one subterminal bristle without, and several terminal ones. Tip of last segment with two stout, curved, claw-like setæ, and four or five smaller, softer ones. Outer lobe of maxilla proper reaching to tip of first segment of palp, nearly equaling it in diameter, also with two curved claws, shorter but much stouter than those mentioned above, three-fourths as long as the lobe itself. Besides these, two smaller setæ and three or more sub-terminal ones, two of which are smooth, like the terminal group, one strongly plumose. A single plumose seta also springs from near the base of the concave surface of this lobe. The second and third lobes similarly armed at the tip, but with a larger number of curved setæ, all of which are soft. Two of these, on the short inner lobe, are much longer and stouter than the others, and project directly backwards. The base of this lobe bears two plumose setæ about as long as those just mentioned. The length of the inner lobe is half that of the outer, the middle one being intermediate.

"The second maxilla with about 12 terminal setæ, which diminish in length inward, most of them slightly plumose, and two long slender setæ, one springing from the middle of the inner margin and the other from the base. Palp thick, slender ovate, twice as long as the masticatory lobe, fringed with a soft silky pile, and bearing three more or less plumose setæ at its tip, the middle one of which is the longest. Branchial lobe very small, semicircular, with three fully developed plumose setæ nearly as long as the palp, and two much shorter ones, one delicate and smooth, the other stout and plumose.

"The basal segment of the second antenna trigonal, with one moderately long hair beneath, and two of similar length springing together from the inner side of the apex. The second segment subcylindrical, with two hairs diverging from the middle of the outer side of the apex, the under one of which is very short and weak, about as long as the third segment is wide, while its companion reaches about to the tip of that segment. On the inside of the tip of the second segment is another hair, similar to the above, and of about the same length. The third segment bears, at the union of its basal with its middle third, on the under side, set beyond a slight tooth-like projection, a jointed olfactory club, whose length is about two-thirds the diameter of the segment. Otherwise this segment bears no hairs except at the tip, where, upon its inferior angle, is one long, stout hair, reaching beyond the tip of the last joint, and upon its inner surface a fascicle of five plumose hairs, the four longer of which are curved and parallel, while the fifth is short and straight. The third segment is slightly longer than the second and about two-thirds as thick. The fourth segment is three-

fourths the length of the third and about two-thirds its diameter, slightly enlarged at the middle, where it bears, on the under side, a group of three long hairs, and upon the upper side two shorter ones. At the tip of the segment are a group of three long plumose hairs and a stout, curved, concave, acute claw, nearly three times the length of the last segment, doubly dentate on both edges. At tip of last segment the usually strong, curved bidentate claws, five in number, three of equal length, as long as the two last segments of the antenna, and two others about half that length.

"Mandible with a row of six dark corneous teeth, more or less bifid, the series continued in an irregular cluster of tooth-like spines, and terminating in two highly plumose setæ. The series of teeth with numerous accessory smaller teeth and spines, and two transparent lamellæ—slender, but as long as the teeth themselves—inserted between the first and second and second and third series, respectively. The latter lamella is recurved and serrate on its concave edge. Basal segment of palp longest, the third next, second and fourth sub-equal in length, the second as broad as the first. The latter bears at its posterior tip three plumose setæ of unequal length, in a cluster, and a fourth larger, stouter, decurved articulate one, inserted on the outer side of the tip of the segment. The second segment has in front a group of three slender setæ inserted a little behind the tip; and opposite to them upon a stout tuberosity another group of three long equal setæ, to which a fourth stands in the same relation as on the preceding segment. On the third segment is a group of five setæ similar to those on the anterior margin of the segment preceding, and, in addition, a circlet of six, attached around the posterior and inner margin of the end of this segment. At the tip of the palp are three curved claws, averaging as long as the two preceding segments together, with some slender setæ intermixed. The so-called branchial appendage is about as long as the basal segment of the palp, and bears four stout plumose setæ with a small accessory seta in front.

"First leg with basal segment columnar, distal portion partially separated, without hair or bristle. Second segment cylindrical, its surface smooth except for numerous transverse rows of exceedingly fine short setæ, present also on the two succeeding segments of this leg. A stout bristle at anterior distal angle. Third and fourth segments nearly equal (the third, however, somewhat the longer), together slightly longer than the second, the length of each about twice its transverse diameter. The third with a single apical hair at the anterior angle, and the fourth with but two, one of which is as long as the segment itself, and the second about half that length. Terminal segment with a very long, slender symmetrically curved, regularly taper-

ing claw, with two short soft setæ springing from its base. The entire claw somewhat longer than the last three segments conjointly.

"Caudal rami long and slender, slightly sinuate, the transverse diameter of each not more than one-twentieth its length; the basal fifth, however, considerably thickened. Rami smooth, except posteriorly, where the margin is closely set with stout, short spines, lengthening toward the distal end of the ramus. Terminal claw slightly curved at the tip, contained two and a half times in the length of its ramus. Subterminal claw nearly two-thirds the length of the terminal, also slightly curved. Claw-like seta almost immediately above the latter, more slender, but two thirds its length. Besides the above, a short slender seta springs from in front of the base of the terminal claw.

"The first and last segments of the second pair of legs sub-equal, each two-thirds the length of the second; basal segment straight, its length five times its width, with three slender setæ, one borne upon the middle of its exterior side, and two near the apex, opposite each other. Second segment slightly curved, with a single slender seta near the apex, on its outer margin. Third segment with two terminal setæ, one nearly straight, claw-like, about three-fourths the length of its segment, and the other curved and blunt."

Habitat: Yellowstone River, Yellowstone Park, Wyoming (S. A. Forbes); (?) Minnesota (Herrick).

To my mind *Candona ornata* Herrick belongs here. But since the figure given by Professor Herrick is about all I have to base my opinion upon, it is not thought wise to enforce this opinion upon the public.

GENUS CYPRIS O. F. Müller, 1785.

In both sexes the antenna is five-jointed. The natatory setæ on the third extend to the tip of the terminal claws.

The mandibular palp does not extend beyond the tip of the mandibular teeth.

The branchial plate of the first maxilla is large, bearing stiff, plumose setæ. The first mandibular process is armed with two biarticulate thorns.

The second maxilla bears a branchial plate.

The second foot resembles that of *Cypridopsis*.

The abdominal ramus is stout, and terminates with two more or less stout claws, in front of which occurs a short and behind which a long seta.

Males are unknown; propagation parthenogenetic only.

Cypris fuscata Jurine.

PLATES LXXI, FIGS. 41-46; LXXII, FIGS. 7-7p; LXXVI, FIG. 9.

1820.—*Cypris fuscata* Jurine (98), p. 174; Pl. XIX, Figs. 1-2.
1837.—? " *adusta* Koch (102), H. II, 3.
1838.— " *galbinea* Koch (102), H. XXI, 19.
1844.— " *fuscata* Zaddach (234), p. 32.
1850.— " *fusca* Baird (5), p. 154; Taf. XIX, Fig. 7.
1850.—*Candona hispida* Baird (5), p. 161; Taf. XIX, Fig. 4.
1853.—*Cypris fuscata* Lilljeborg (118), p. 114; Pl. X, Figs. 6-9; Pl. XII, Fig. 5.
1868.— " *fusca* Brady (18), p. 362; Pl. XXIII, Figs. 10-15.
1887.— " *dugesi* C. L. Herrick (86), p. 26; Pl. IV, Fig. 7.
1888.— " *fusca* Sostaric (202), p. 47.
1889.— " *fuscata* Brady and Norman (31), p. 73; Pl. XII, Figs. 3-4.
1891.— " *fuscata* Wenzel Vavra (221), pp. 98-99, Figs. 33, 33^1-33^3.
1894.— " *fuscata* C. H. Turner (215), pp. 16-17; Pl. VII, Figs. 41-46.
1894.— " *fuscata* C. H. Turner (216).

Length of the female 1.40 mm. to 1.50 mm. Height 0.9 mm. Width 0.67 mm. to 0.73 mm.

The greatest height of the animal is about two-thirds of the length, while the greatest width is less than the height. The color is greenish brown. The shell usually has attached to it furfaceous matter, which Professor Brady thinks is desquamating epidermis.

Viewed from the side the cephalic third of the shell is wider than any other portion. The caudal, dorsal and cephalic borders are convex. The cephalic and caudal margins have a narrow hyaline edge. The valves are not very transparent and are covered with short, scattered hairs. Muscle impressions near centre of the valve, about seven.

Viewed from above the shell is oval, rounded behind and bluntly pointed in front. The greatest height is in the middle.

The natatory setæ of the antennæ extend to the tips of the terminal claws. The terminal claws are stout, curved and longer than the last two joints. The distal half of the inner margin of each claw is pectinated with a double row of fine teeth.

The two enlarged spines upon the first mandibular process are toothed. The extremity of each spine and the two adjacent teeth are blunt.

The first foot is five-jointed, the third and fourth joints being distinct. The terminal claw is long and stout, longer than the combined lengths of the last three joints. The second joint is stout and about as long as the combined lengths of the next two joints.

The terminal claw of the second foot (Fig. 43) is about twice as long as the terminal joint.

The feebly-curved post-abdomen (Fig. 46) is stout and short. The terminal claw is a little more than half as long as the abdominal ramus. The adjacent claw is about three-fourths as long as the terminal claw.

Habitat: Cincinnati, Ohio (Turner, 213); Guanajuata, Mexico (Herrick, 86); Albuquerque, New Mexico.

Cypris virens Jurine.

PLATE LXXIV, FIGS. 3-3e.

1820.—*Monoculus virens* Jurine (98), p. 174; Pl. XVIII, Figs. 15-16.
1838.—*Cypris gibberata* Koch (102), H. XXI, 20.
1844.— " *virens* Zaddach (234), p. 35.
1844.— " *pilosa* Zaddach (234), p. 36.
1850.— " *tristriata* Baird (5), p. 152; Taf. XVIII, Figs. 1, 1a-1i, 2-3.
1851.— " *ornata* S. Fischer (63), p. 157; Pl. IX, Figs. 7-10.
1853.— " *virens* Lilljeborg (118), p. 117; Taf. VIII, Fig. 16; Taf. IX, Figs. 4-5.
1868.— " *virens* Brady (18), p. 364; Pl. XXIII, Figs. 23-32; Pl. XXXVI, Fig. 1.
1868.— " *pubera* Fric and Nekut (70), p. 46, Fig. 26.
1870.— " *ventricosa* Brady and Robertson (33), p. 12; Pl. IV, Figs. 1-3.
1872.— " *pubera* Fric (69), p. 226.
1874.— " *virens* Brady, Crosskey and Robertson (30), p. 124; Pl. II, Figs. 27-28.
1887.— " *Helena* Moniez (135), p. 2.
1887.— " *virens* C. L. Herrick (86), pp. 24-26; Pl. VI, Fig. 3.
1889.— " *virens* Brady and Norman (31), p. 77.
1891.— " *virens* Wenzel Vavra (221), pp. 102-104, Fig. 3; Figs. 4, 4^1, 4^2, 4^4; Figs. 5, 5^1-5^2; Figs. 36, 36^1-36^4.

Only once have I encountered an American form which I supposed was *Cypris virens*. Then the specimens were accidentally destroyed before accurate drawings were made. Mr. Deming, however (Herrick, 86), claims to have found this species to be quite abundant at Granville, Ohio. The following description is due to Mr. Deming. I have taken the liberty to omit much that is merely generic and to add, in brackets, some specific characters.

"Valves sub-reniform, the two ends almost equal, the dorsal side evenly curved, the ventral side sinuated, highest in the middle. The valves are covered with minute hairs. The hinge-line is sinuated and unbroken. The outer part of the shell is slightly lined. The shell as seen on end is oval; seen from above, oblong-ovate. Lucid spots, about seven in number, are found in about the centre of the valves; these are oblong and irregular in shape, often pointing towards the ventral margin. Isolated spots are found near the dorsal side. The color is olive or yellowish green, with dark brown spots near the dorsal margin and scattered throughout the shell. * * * * * * *

[The two biarticulate spines on the first mandibular process of the first maxilla are smooth.]

"The post-abdomen forms two long, movable rami, which are well developed and terminated by two claws of unequal length, and in fine specimens are serrated on their inner edge near the apex. The rami themselves are also serrated." [In European specimens and in specimens taken by the present writer to belong to this species the abdominal rami are not serrated.]

Mr. Deming claims to have found the male of *Cypris virens*. I have reason, however, for supposing that he has confounded the males of some other species (perhaps *C. crena*) with *Cypris virens*.

Habitat: Granville, Ohio (Herrick, 86).

Cypris perelegans Herrick.

PLATE LXXIII.

1887.—*Cypris perelegans* C. L. Herrick (86), p. 27; Pl. III, Figs. 7-12.
1894.—*Cypris perelegans* C. H. Turner (216).

Length 3.60 mm. Height 1.72 mm. Width 1.40 mm.

"Carapace of largest size, elongate sub-oblong, sides nearly parallel, upper margin nearly straight, lower outline with two sinuses and two slight convexities, produced to form a slight tooth behind; greatest height at one fourth the length from the posterior, equal to less than half the length; width greatest somewhat in advance of the middle, about four-tenths the length; color clear, pale yellow, with a well-defined pattern in deep brown, pattern consisting of a sigmoid band crossing the middle of the valves, giving off spurs at each flexure, and sundry other spots, as well as an anterior marginal band; surface shining, minutely dotted, slightly hairy at margins; lucid spots consisting of two large irregularly pentagonal approximated spots, with three smaller ones grouped below; appendages very similar to *C. virens;* antennæ seven-jointed, slender, basal segment very large, third elongated, four succeeding nearly equal in length, fourth and fifth segments each with two long setæ above, sixth with four long and one shorter setæ, apical segment with four very long setæ, fifth segment with two setæ of moderate length below; antennules (antennæ) slender, apical segment with two serrate claws and two slender setæ, fourth (antepenult) segment the same, third segment with four long and two shorter setæ, second segment with six long pectinate setæ reaching to end of terminal claws; labrum with claw-like appendages bearing seven teeth, the inner being double, medianly the labrum appendaged with pectinate plates; the mandibles furnished with six strong teeth, two pectinate setæ and several small spines, the palp being well-developed; first maxilla with short lobes, the anterior of the one-jointed lobes with four very strong toothed spines; first foot with five segments, the apical one being very small and bearing a single very long

serrated claw, the third and fourth are equal and much more slender than the second; second foot slender, apical segment with two small claws and one delicate seta, caudal stylets elongated, narrow, serrate behind, with two straight, unequal serrate claws, lateral spine subterminal." (Herrick, 86.)

Habitat: Mobile, Ala. (Herrick 86.)

Cypris altissimus Chambers.

PLATE LXXIX, FIGS. 10-13.

18—.—*Cypris altissimus* Chambers (41), pp. 152-153, Fig. 2.
1887.—*Cypris altissimus* C. L. Herrick (86), p. 27.

Length 1.26 mm. Height 0.63 mm.

"Valves oblong, slightly subreniform, highest about the middle, rounding regularly before and behind; the side view resembling somewhat Baird's figure of *C. tristriata*, but less distinctly reniform, perhaps rather resembling in the form of the dorsal margin *Cypridopsis vidua*; it is, however, much more elongate in proportion to height. Brady's figure of *C. virens* (=*C. tristriata* Baird) is a little nearer to this species, but is too distinctly reniform. *C. virens* also agrees with this species in the number (seven) of the lucid spots, and approaches it in their position on the shell, and in relation to each other, but they differ in shape. In this species, the extremities are more nearly equally rounded than in *virens*, the dorsal margin being evenly rounded before and behind the middle, and the ventral likewise, both before and behind the slight sinuation in the middle. But the anatomy of the appendages differs more decidedly from that of *virens*, as will be seen by a comparison of the following account with Brady's figures. Superior antennæ with only twelve instead of fourteen long setæ, arranged as follows: There are two short setæ (one longer than the other) from the third joint, which has none in Brady's figure; two short and two long ones from the fourth joint, where *virens* has four long ones; three long ones and one shorter one from the fifth joint, which in *virens* has four long ones; four long ones from the sixth joint, where *virens* has only three, and three long ones and one short one from the last joint, where *virens* has three long ones. In the inferior antennæ similar differences are found, and in the mandibular palpus even greater ones. The feet of the first pair appear to be identical in the two species, except that this species has a short seta on each of the joints three and four, which are not represented in Mr. Brady's figure. His figure, however, shows one seta more on each of the joints two and three of the feet of the second pair than I find in this species, which likewise is much smaller than *C. virens*, being only one-twentieth of an inch long and one-fortieth high instead of one-fourteenth of an inch long and

one twenty-fifth high, as in *virens*. In ventral and dorsal view it also resembles *virens*. Surface smooth pubescent, with minute punctures. Color bright deep green." (Chambers.)

This species has not been seen by me. It certainly is very closely related to *Cypris virens*, and may prove to be that species. For the present, however, it is thought best to regard it as a distinct species.

Habitat: Pond fed by melting snow, Mount Elbert, Colorado. Altitude, about 12,000 feet. (Chambers, 41.)

Cypris herricki Turner.

PLATES LXVII, FIGS. 1-10; LXVIII, FIGS. 40-42; LXIX, FIGS. 32-39.

1892.—*Cypris Herricki* C. H. Turner (212), pp. 71-73; Pl. II, Figs. 1-10.
1893.—*Cypris Herricki* C. H. Turner (213), pp. 11-15; Pl. I, Figs. 33-39; Pl. II, Figs. 40-42.

Length 3.0 mm. Height 1.70 mm. Width 1.43 mm.

In a lateral view, the shell is sub-triangular, highest near the middle. The ventral margin is straight, excepting at the cephalic extremity, where, after a shallow concave notch, the margin is convex. The remainder of the margin is strongly convex. From the above described ventral notch, a well defined, feebly convex, line passes dorsad to the opposite margin. That portion of the shell which lies cephalad of this line is usually curved laterad. From within the cephalic and caudal extremities of the valves numerous hairs protrude.

In a dorsal view, the shell is sub-fusiform, being widest caudad of the middle. At their caudad extremity the valves are slightly divaricated, while at their cephalad extremity they are closely approximated. The shell is covered with fine reticulations and minute hairs. In addition to these, it is marked with conspicuous dark green bands. These bands are arranged as follows: One, parallel to and almost adjacent to the mesal border of the shell, extends from the caudo-ventrad angle of the shell dorso-cephalad almost to the cephalad extremity of the valve. There it divides. One portion continues in the same course to the cephalo-ventral extremity of the valve. The other, turning laterad, passes ventrad for a short distance and terminates in a sharp point. At the origin of this line there is a large, convex blotch, which extends ventrad a short distance. Near the centre of the figure several bands fuse in such a manner as to form a hollow, sub-square figure. From the cephalo-dorsal corner of the square a tongue passes ventro-caudad into the square. The length of this tongue and the angles it makes with the sides of the square vary slightly in different individuals. Usually it extends almost to the centre. From this same angle of the shell a band projects ectad. After passing cephalad a short

distance, this band forms a convex curve and passes caudo-dorsad almost to the margin of the shell. From the caudo-dorsal angle of the square a short band passes dorso caudad and fuses with a broader band which passes caudad, approximately parallel to the dorsal margin of the shell. From this same corner another band passes caudo-ventrad almost to the caudal margin of the shell. This band is approximately parallel to the band just described. From the caudo-ventral angle of the square a band passes caudo-ventrad almost to the caudo-ventral extremity of the shell. In the caudal portion of its course this band curves dorsad, otherwise it is approximately parallel to the band last described. From the cephalo-ventral angle of the square, a short band projects ventrad and then broadening, forms a boot-shape band. The short heel of this boot projects caudad and terminates in a point, the long toe extends cephalad and terminates bluntly. From the same corner of the square, a second band projects cephalad to about the level of the toe of the boot. There it fuses with a spike shaped band which extends cephalo-ventrad from near the cephalo-dorsal angle of the square to about the cephalo-ventral extremity of the shell. The head of the spike is at the caudo-dorsal extremity of the band. The two bands fuse near the head.

The number of lucid spots is about eight. They are situated in the centre of the valve and ordinarily are inclosed within the square above described.

Viewed from the ventral surface one valve overlaps the other in front. The contact line is sinuous, being laterally convex at the middle.

Viewed from the end the shell is oval in shape, the greatest width being near the dorsal surface.

Antennæ slender; the natatory setæ on the distal extremity of the third joint reach almost or quite to the tip of the long and slender terminal claws.

The mandible is stout. Among other setæ, the antepenultimate joint of mandibular palp bears a short, pectinated, dagger-shape seta; so does the penultimate joint.

The two biarticulate claws on the first mandibular process of the first maxilla are smooth. The extremity of that same process bears two setæ as long as the biarticulate claws; one, which is curved and smooth, is situated at the outer angle and the other, which is straight and pectinated, is situated about the middle of the extremity.

The terminal claw of the first leg is almost as long as the entire limb. The distal two-thirds is pectinated.

The post-abdomen is long, slender and straight. The distal portion of its outer margin is pectinated. The terminal claws are curved and are a little longer than half the length of the abdominal rami.

Habitat: Cincinnati, Ohio. Very abundant in a shallow canal basin in Camp Washington. Up to date it has not been found in any other locality.

LATE LARVAL HISTORY OF CYPRIS HERRICKI.

PLATES LXVIII, FIGS. 40-42; LXIX, FIGS. 33-39.

In this connection it is not intended to discuss the early stages of *Cypris Herricki*. These remarks will be confined to what corresponds to the seventh to ninth ecdyces of *Cypria opthalmica* Jurine. Not only that, but the remarks will be restricted to the external morphology. It is hoped to discuss the internal anatomy in a subsequent paper.

The earliest stage here discussed has been compared to the seventh stage of *Cypria opthalmica* Jurine, because in that stage the appendages have attained about their permanent form; but it must not be supposed that in this *Cypris* there are only two subsequent larval stages. These stages are tabulated in the following table:

Stages.	Length.	Height.	Position of Dorsal Hump, Etc.	Form of Post-abdomen.
A	0.90 mm.	0.57 mm.	Some distance in front of middle. Teeth on caudal margin of shell.	Rudimentary; fewer spines than in adult; terminal about as long as or longer than remainder of the appendage.
B	1.32 mm to 1.38 mm.	0.71 mm. to 0.84 mm.	Approaching middle. Teeth on shell much larger.	Form normal; number of spines normal; ratio of the length of the post-abdomen greater than in adult.
C	1.98 mm.	1.20 mm.	Near the middle. Teeth on shell large.	Ratio of the length of terminal spine to the length of post-abdomen more nearly normal than in B.
D	2.79 mm.	1.64 mm.	At middle. Teeth disappearing.	About as in adult.
Adult.	3.00 mm.		At middle. No teeth on shell.	

In *Cypria opthalmica* (Jurine) Claus found that by the time the seventh stage was reached, the shell had practically assumed its final form. In the form here described there are pronounced differences between the earliest stage here considered and the adult.

In the adult of *Cypris Herricki* the dorsal border of the shell is almost uniformly convex and the cephalic border of the shell is about the same height as the caudal. In stage A (Fig. 33), however, the shell is highest near the cephalic extremity, and the cephalic border of the shell is higher than the caudal. As the animal passes through stages B to D, the highest point of shell moves gradually towards the middle and the height of the caudal margin of the shell approaches more and more the height of the cephalic margin.

In the adult *Cypris Herricki* the caudal margin of the shell is entire. But in stage A, the caudal margin of the shell is bordered with minute teeth (Fig. 34). In this stage the teeth are quite small and might easily be overlooked; but in stage B (Fig. 35), these teeth have become very conspicuous. Indeed, they are the characteristic feature of the shell. These teeth are present throughout stages A to D, but in stage D they have begun to disappear. In the adult stage there is no trace of these teeth.

A careful study of the adult shows that the shell is covered with hairs. These hairs are very conspicuous in stage A. The shell of the adult is marked with very conspicuous dark bands.

An effort has been made to discover at what period these bands appear, and to see if they conform to the rules laid down by Professor Eimer. The characteristic bands on the shell may be present in any stage from A to the adult; and when they are present they do not differ essentially from the markings on the adult. The chief points of difference being variations in the width of the bands. In all examples of stages C and D examined, these characteristic markings were found; but in stages A and B, they were occasionally absent. An examination of Fig. 35 will show that some of these bands are longitudinal while others are oblique.

Professor Eimer has attempted to establish the following rule for the formation of oblique markings on animals.* Oblique markings first appear as longitudinal lines. These lines become resolved into dots, these dots, in turn, rearrange themselves in oblique lines. If these laws were applicable to the markings on *Cypris Herricki*, in stages A and B, where we have some specimens with bands and others without them, we ought to find some transition stages—some stages in which the oblique markings were represented either by parallel lines, or by series of dots. But such is not the case. The shell is either unmarked by bands, or both oblique and longitudinal bands are present.

As stated above, in stage A the appendages have practically assumed their permanent form. The post-abdomen is a notable exception. This appendage is quite rudimentary; not only has it not yet acquired the typical number of setæ, but the longest terminal seta is as long as, or longer than, the remainder of the post-abdomen. This great relative length of the terminal seta is due, not to an over-development of the seta, but to an under-development of the body of the post-abdomen. That the post-abdomen appears to be the last appendage to development is rendered more striking by the discovery of C. Claus that the post abdomen appears before the formation of the sec-

* *G. H. Th. Eimer.* Organic Evolution as the Result of the Inheritance of Acquired Characters According to the Laws of Organic Growth. Translated by J. T. Cunningham, 1890. P. 73.

ond pair of legs. In stage B the post-abdomen has developed the permanent number of setæ, but the ratio of the length of the terminal seta to the length of the body of the member is much greater than in the adult. In passing through stages C and D, the parts of the post-abdomen gradually assume the proportions of the adult.

Every precaution has been taken to be sure that all the stages above described were stages of one and the same animal. A definite number of each stage was isolated in saucers of water and a record kept of the number placed in each saucer, and also of the stage of growth exhibited by each set at time of isolation. The water used was collected from a pool which did not contain any *Ostracodes* which in the least resembled those under consideration. As a further precaution the water was allowed to stand in the laboratory a couple of weeks. The loss in volume was replaced by river water, taken from the city hydrant. I never have found any *Ostracoda* in said river. Thus there was no possibility of the water containing the eggs of *Cypris herricki*. The larval stages which were placed in this water were examined from time to time. In every case the specimens devel oped into the adult form.

The morphological differences between the shell of stage B and the shell of stage A, and between the shell of stage B and the adult, are certainly as great as the morphological differences between the shells of closely allied species. The morphological differences between stage A and the adult are differences, not only in the shell structure, but also in the structure of the post abdomen. And these differences are as great as those between the genus *Cypris* and the genus *Cypridopsis*. These facts show that shell structure of *Ostracodes*, when taken alone, is of almost no taxonomic value.

These facts also have phylogenetic significance. These various larval stages are resting stages in the development of *Cypris herricki*. Since it is true that the ontogenetic development of an individual is a rapid and compact repetition of its phylogenetic history, these larval forms must represent past stages in the evolution of *Cypris herricki*. As has been stated above, stage A corresponds very closely to the genus *Cypridopsis*. The main distinction between the genus *Cypris* and the genus *Cypridopsis* is the difference in the form of the post-abdomen. In the genus *Cypridopsis* the body of the post-abdomen is but slightly developed, while the setæ are quite long. In stage A, in the larval history of *Cypris herricki* the post-abdomen is in this rudimentary condition; thus it corresponds very closely to the genus *Cypridopsis*. Not only that, but the unbanded forms of this stage correspond very closely to *Cypridopsis hystrix* Herrick.* Indeed, when this stage

*C. L. *Herrick*. Contribution to the Fauna of the Gulf of Mexico and the South. 1887. P. 30, Pl. V, Fig. 6.

was first encountered, it was supposed to be a *Cypridopsis*. While working at its anatomy a specimen with the markings characteristic of *Cypris herricki* was discovered. This led to an investigation of the larval history of the crustacean.

These facts give us a very strong hint that the genus *Cypris* has been evolved directly from the genus *Cypridopsis*. Should future research show that all members of the genus *Cypris* have a *Cypridopsis* stage, the discovery would give much weight to the hint. And if, at the same time, the internal structure should prove to be similar, the evidence would be conclusive.

Cypris (?) albuquerquensis sp. n.

PLATE LXXVIII.

Length 0.5 mm. Height 0.28 mm. Width 0.35 mm.

This is a small greenish hirsute shell about twice as long as high and much wider than high.

Viewed from the side (Fig. 1) it is sub-reniform. The two extremities are rounded, but the cephalic is broader than the caudal. The dorsal margin is convex, the ventral nearly straight.

Viewed from above (Fig. 2) the shell is a broad oval, widest near the middle. The cephalic extremity is a trifle narrower than the caudal. Hingeline straight.

The terminal claws of the antenna are long, slender and non-pectinate. The natatory setæ on the antepenultimate joint do not extend beyond the tip of the terminal claws.

The feet are stout.

For details consult Plate LXXVIII, Figs. 1-7.

This species has not been encountered by the author. The description is based on drawings furnished by Professor C. L. Herrick.

Habitat: Albuquerque, New Mexico.

The data at my disposal render it impossible for me to rightly classify or characterize the following species: *C. agilis* Haldeman (78), *C. discolor* Haldeman (78), *C. scabra* Haldeman (78), *C. simplex* Haldeman (78), *C. vitrea* Haldeman (78), *C. hispida* De Kay (58).

GENUS CYPRINOTUS Brady. 1885.

This genus was first established by Professor Brady (26) in 1885 to include a peculiar form that had been discovered by Mr. A. Haly in Ceylon. Professor Sars (195) in 1889 amended the genus in such a way as to make it include all the sexually propagated forms of the old genus *Cypris*. In this paper Professor Sars' description has been

sufficiently modified to include the American forms that propagate sexually. It is presumed that Professor Wenzel Vávra, who objects to the genus *Erpetocypris* (221), will also object to this one. The species of this group, however, are closely related both anatomically and physiologically, and it is thought that most workers will welcome the division of the old genus *Cypris* into the several genera here given.

Shell rather thin, compressed, oval or sub-triangular, height exceeding half the length, dorsal margin strongly arched, ventral almost straight. Valves usually unequal, the left valve overlapping the right. The free edges of left valve smooth, cephalic and caudal extremity usually bordered with a hyaline flange. The free cephalic end of right valve usually armed with tuberculiform teeth. Natatory setæ of antennæ reach beyond the tip of the terminal claw. Abdominal rami are slender, with smooth or very finely pectinated claws.

Propagation is sexual. Copulative organs are small, with an outer linguiform obtuse plate. The cylindrical core of Zenker's organ bears numerous wreaths of spines.

Cyprinotus incongruens Ramdohr.

PLATE LXVIII, Figs. 9-16.

1808.—*Cypris incongruens* Ramdohr (173), p. 86; Taf. III, Figs. 1-12, 15, 16, 18-20.
1820.—*Monoculus conchaceus* Jurine (98), p. 171; Pl. XVII, Figs. 7-8.
1820.— " *ruber* Jurine (98), p. 172; Pl. XVIII, Figs. 3-4.
1820.— " *aurantiacus* Jurine (98), p. 173; Pl. XVIII, Figs. 5-12.
1821.—*Cypris fusca* Straus (205), p. 59; Taf. I, Figs. 1-16.
1844.— " *aurantia* Zaddach (234), p. 37.
1844.—? " *opthalma* Koch ('02), H. 36, p. 17.
1850.— " *aurantia* Baird (5), p. 159; Taf. XIX, Fig. 13.
1853.— " *incongruens* Lilljeborg (118), p. 119; Taf. IX, Figs. 6-7; Taf. XI, Figs. 1-4; Taf. XII, Fig. 6.
1855.— " *aurantia* S. Fischer (65), p. 650; Pl. I, Figs. 29-31, 60, 61.
1868.— " *incongruens* Brady (18), p. 73; Pl. XXIII, Figs. 16-22.
1868.— " *fusca* Fric and Nekut (70), p. 47, Fig. 28.
1872.— " *fusca* Fric (69), p. 212, Fig. 26.
1889.— " *incongruens* Brady and Norman (31), p. 73; Pl. XII, Figs. 8-9.
1891.— " *incongruens* Wenzel Vávra (221), pp. 95-98; Figs. 32, 32^1-32^6.
1893.— " *incongruens* C. H. Turner (213), p. 8; Pl. I, Figs. 9-16; Pl. II, Figs. 17-21.

Length 1.35 mm. Height 0.75 mm.

The shell is equivalve, one valve overlapping the other in front. The shell is yellowish brown in color and is covered with scattered hairs.

Viewed from the side (Fig. 9) the shell is sub-reniform, widest near the middle. Both extremities rounded and of nearly the same width; the cephalic extremity may be a trifle narrower than the caudal. Ventral margin nearly straight, other margins convex.

Viewed from above (Fig. 10) the shell is ovoid, pointed in front and rounded behind. The greatest width is caudad of the middle. Hingeline straight.

Viewed from below (Fig. 11) the contact line is straight.

The claws on the antenna (Fig. 13) are toothed. The plumose natatory setæ reach to the extremity of the terminal claws.

No dagger-shaped seta visible on either the penultimate or antepenultimate joint of the mandibular palp.

The biarticulate claws on the first mandibular process of the first maxilla toothed.

The claw of the first foot is long, slender, finely pectinated and curved.

The abdominal ramus is short, feeble and slightly curved. The terminal claw is long, slender, slightly curved, pectinated near the end. The claw is about two-thirds as long as the entire ramus.

I have never encountered any males of this species; but since Wenzel Vávra (221) has found males of this species in Bohemia, and since it is anatomically closely related to the other members of this group, I include it in this genus.

Habitat: Rare. Cincinnati, Ohio (Turner, 213).

Cyprinotus crena Turner.

PLATES LXVII, FIGS. 11-13; LXIX, FIGS. 22-31.

1892.—*Cypris sp.* (?) C. H. Turner (212), p. 71; Pl. II, Figs 11-13.
1893.— " *crenata* C. H. Turner (213), p. 9; Pl. II, Figs. 22-32.

Length of female 1.23 mm. Height 0.63 mm. Width 0.60 mm. Length of male 1.14 mm. Height 0.60 mm. Width 0.45 mm.

The shell is equivalve, very thin, the free margins of one valve are bordered with blunt teeth. The ventral margins of both valves bear hairs. Shell reticulated with contorted lines; the reticulations are most distinct on the cephalic portion of valve. Lucid spots about nine, sub-central. Color, various shades of greenish yellow. The caudal half of shell of male appears to be marked with concentric retort shaped lines. Since the shell is very thin this appearance is due to the presence of spermatozoa or spermatophores within the shell.

Viewed from the side (Fig. 22) the shell is sub-reniform, highest about the middle, cephalic and caudal extremities about the same width. Caudal, dorsal, and cephalic margins convex; ventral margin nearly straight, slightly convex at the middle.

Viewed from above (Fig. 23) the shell is sub-oval, widest behind the middle. Caudal margin rounded, cephalic margin bluntly pointed. Hingeline sinuate.

Viewed from below (Fig. 24) same as when viewed from above. Line of contact of valves sinuate.

Viewed from end (Fig. 25) shell is oval, a little higher than wide.

Antennules (Fig. 25) and antennæ as usual in genus *Cypris*.

The mandible (Fig. 26) terminates in four large teeth; between each two of these teeth there is a short, slender rod. The mandibular palp consists of four joints. The first joint is very large, about as large as the combined lengths of the other three; it bears about the middle of its dorsal surface a branchial appendage, which in turn bears four long setæ; and from the distal fifth of its ventral surface arise two long setæ. The antepenultimate joint is very short; from the distal half of its dorsal surface arise two long setæ and one short one. The penultimate joint is long; from its disto dorsal extremity arise three long and one short setæ; from the disto-ventral angle of the shell arise two short setæ. The terminal joint is very narrow and about as short as the antepenultimate joint; at its tip it bears four short claws.

The biarticulate claws on the first mandibular process of the first maxilla are smooth.

The first foot of the male (Fig. 27) is composed of five joints. The second joint is large. The antepenultimate joint is about as long as the preceding joint. From its disto-caudal margin arises a medium sized seta, and from its disto-cephalic margin arises a somewhat smaller seta. The terminal joint is about the same size as the penultimate. From its disto-caudal margin arise a medium size seta and a small spine: from its disto-cephalic margin arises a very short spine. From the distal end of joint arises a long claw; the claw is about as long as the combined lengths of the three distal joints. The claw is composed of a short basal and a long terminal portion. At the disto-caudal portion of the basal joint of claw there is a short seta; at the disto-cephalic margin of the same joint there is a somewhat smaller seta. A row of fine hairs extends along the middle portions of the caudal margin of the terminal joint of the claw.

In the second foot of the male the antepenultimate joint is medium sized. From about the middle of this joint arises a median seta, and from the disto-caudal margin a long seta. The penultimate joint is the longest joint; from its disto-cephalic margin arises a median spine. The terminal joint is about as long as the antepenult; from the middle of its cephalic border arises a short seta; from its tip arises a short seta; from its tip a more or less curved short claw and a median seta.

The post-abdomen (Fig. 29) of male is curved. At its tip there is a long claw and a short seta. Entad of this terminal claw is another long claw: further entad arises a short seta. Post-abdomen of female is straighter, otherwise the same.

In the male there is a pair of verticillate sacs (Fig. 30). From the distal extremity of each arises a vas deferens. Length of sac 0.35 mm.; width 0.11 mm. The copulative organ of male consists of distinct halves, each half of which is composed of a large basal and a small terminal portion. The basal portion of each division receives at its proximal end a vas deferens. Length of copulative organ 0.37 mm.; width 0.11 mm.

Habitat: Small weedy ponds or canal basins. I have not found these very often; but whenever found they were very abundant. On one occasion I found a pool containing millions of males, but not a single female. Specimens of this species have been found at Cincinnati, Ohio. (Turner, 213.)

Cyprinotus burlingtonensis Turner.

PLATE LXX, FIGS. 14-23.

1894.—*Cypris burlingtonensis* C. H. Turner (215), pp. 17-19; Pl. VII, Figs. 14-23.
1894.— " *burlingtonensis* C. H. Turner (216).

Length of the female 1.6 mm. Width 0.89 mm. Height 0.93 mm. Length of the male 1.3 mm. Width 0.7 mm. Height 0.7 mm.

The length of the shell is a little less than twice the width and the height is about equal to the width. The shell is very thin and is covered with long hairs (Fig. 15). The shell is also marked with certain dark bands, which are due, in part at least, to the internal organs shining through the translucent shell.

Viewed from the side (Fig. 17) the shell is sub-oval, but the cephalic extremity is wider than the caudal. The dorsal margin is convex, the greatest convexity being nearer the cephalic than the caudal extremity. The cephalic and caudal margins are convex. The ventral margin is nearly straight.

Viewed from above the shell is sub-elliptical, the two extremities being more or less pointed (Fig. 17) and of about equal width. In some specimens the ends are round. The sides are feebly convex, indeed in some parts they are almost straight and nearly parallel.

Viewed from the end the shell is nearly circular, the sides being very convex.

The antenna consists of five joints (Fig. 20), the fourth joint being very long and slender. The distal joint is narrow, being no wider than the base of the terminal claws. The terminal claws are slender and the distal portion of each is fringed by a longitudinal row of very fine teeth. The natatory setæ extend to a short distance beyond the tip of the terminal claws.

The second joint of the mandibular palp bears, in addition to the usual setæ, a short, plumose, dagger-shaped seta (Fig. 18). The terminal claws of the palp are slender and smooth.

The two prominent spines upon the first mandibular process of the first maxilla bear teeth (Fig. 16).

The palp of the second maxilla terminates in three long flexible spines. The middle spine is longer than the whole palp, but the lateral ones are only about two-thirds as long as the middle one.

The first foot (Fig. 21) is five-jointed, the third and fourth joints being distinct. The second joint is broad and is as long as the united lengths of the next three joints. The terminal claw is longer than the united lengths of the last three joints. The distal third of the cephalic margin of this claw is finely pectinated.

The claw upon the last joint of the second foot (Fig. 23) is curved and is about twice as long as the terminal joint.

The post-abdominal rami (Fig. 19) are slender and straight. The terminal claws are long and slender, being about half as long as the ramus. They are straight and one margin of the tip of each is finely pectinated. The lower claw is fully three-fourths as long as the distal one and resembles it in structure.

Habitat: These are found in great numbers in a shallow grassy pool at Burlington, Ohio. They were found in the early part of March, 1893, just after the close of a long and severe winter; indeed, there was a light snow-fall the day before the collection was made. Judging by the lay of the land, I think that the pool dries up in summer.

At Atlanta, Georgia, just after some heavy rains in January, 1894, large numbers of these active creatures were found in several shallow pools in the South River bottoms. These pools dry up in warm weather. The specimens remained for about two weeks and then disappeared. Length 1.58 mm.; height 0.94 mm.; width 0.91 mm. Jones Creek, Kent county, Delaware, March 3, 1894, collected by Professor L. D. Hileland. These were immature specimens about 1.4 mm. long.

Cyprinotus grandis Chambers.

PLATE LXXIX, FIGS. 1-9.

——.—*Cypris grandis* V. T. Chambers (41), pp. 151-152, Fig. 1.
1887.—*Cypris grandis* C. L. Herrick (86), p. 32.

Length 3.60 mm. Height 2.09 mm. Width 1.39 mm.

"Valve oblong, slightly sub-reniform, highest behind the middle, sloping thence regularly toward the anterior end, with a slight bulge on the hinge-margin just where it rounds off in front. Greatest thickness about the middle. In side view somewhat resembling Brady's

figure of *C. tessellata* (Trans. Linn. Soc., v. 26, Pl. 23, Fig. 39), but this species is longer in proportion to height and has the highest point of the dorsal margin a little farther behind. Ventral margin very slightly emarginate. In dorsal and ventral view somewhat resembling Brady's figure of *Macrocypris minna* (loc. cit., Pl. 28, Fig. 34). Right [? left] slightly overlapping the left [? right]; surface smooth, with minute punctures and short hairs, but with a group of scattered, large sordid, yellowish punctures about the middle of each valve. Color bluish-white (nearly that of thin milk), though some specimens show a decided pale greenish tinge. Basal joint of superior antennæ with two short setæ above and one below; second joint with a single short one below; third with two short unequal setæ above and one below; fourth with two above like those of the third, and two long ones below; fifth as the fourth; sixth with the two upper setæ as in the third and fourth, but with four long ones below; seventh with two long and two shorter setæ. Inferior antennæ with one moderately long and two short claws, and two setæ from the end of the last joint, and with four long claws (one shorter than the other three), and one moderately long seta, and one long one from the end of the penultimate joint, besides four rather long ones above, and two beneath about its middle. Third joint with the usual single stout seta from its end beneath, and the usual fascicle of five long and one short one above near the end, and the usual articulated process. Post-abdominal ramus similar to that of *C. incongruens* as figured by Brady (loc. cit., Pl. 23, Fig. 20), but longer, having three unequal setæ, the terminal one longest. Seminal gland very similar to that of *Notodromas monachus* (loc. cit., Pl. 37, Fig. 36). Length $\frac{1}{7}$ of an inch; height $\frac{1}{12}$; greatest thickness $\frac{1}{18}$. Probably the largest known species of the genus. It is abundant in the ponds along the upper Arkansas river in the Mount Harvard region, at an altitude of about 8,000 feet. When first taken, my specimens were brownish from adhering mud, but alcoholic specimens have the livid white color above mentioned. The lucid spots are indistinct and difficult to make out; there are about nine, the two anterior obliquely transverse and long, the two posterior small." (V. T. Chambers.)

Habitat: Upper Arkansas river in Mount Harvard region. (V. T. Chambers.)

FAMILY DARWINULIDÆ.

"Antennæ destitute of swimming setæ and of poison gland and duct. Mandible-palp three-jointed; the basal joint large and densely setiferous. Two pairs of jaws, the first bearing a large branchial plate, the second a smaller branchial plate and a pediform palp. Two pairs of feet external to the valves. Post-abdominal lobes sub-conical, small." (Brady and Norman.)

GENUS DARWINULA Brady and Robertson. 1870.

"Shell smooth, thin, and fragile. Carapace oblong, higher behind than in front; lucid spots ten to twelve in number, linear-oblong or wedge-shaped, arranged in a subradiate manner in front of the centre of the valve. Seen from the side, compressed, oblong, sub ovate. Seen from above, ovate, acuminate in front, obtusely rounded behind. Valves unequal, the right much larger than the left. Antennules very short, six-jointed, and stout, strongly armed with short and stout curved setæ. Antennæ four-jointed, and bearing four or five strong terminal claws; entirely destitute of poison gland or urticating setæ, the place of which is occupied by a single curved seta of moderate length. Mandible broad, truncated at the distal extremity, which is provided with six or seven small spiniform teeth; palp three jointed, its basal joint very wide and fringed with several curved setæ, bearing also a small lamina, fringed with branchial filaments; second joint long, slender, and nearly four times as long as broad, slightly curved and dilated at the distal extremity, where it bears one long and two small setæ; terminal joint more slender, about two-thirds of the length of the foregoing, and bearing at the truncate apex about six slender curved spines. First maxilla divided into four short setiferous segments, and bearing a very long oblong palp, which is fringed with about twenty-four long branchial filaments, and has also four other long setæ at its base. Second maxilla simple, short, and broad, truncate at the apex, and fringed on the distal margin with several slender spine-like hairs, bearing also a large, three-jointed, pediform palp, and an ovate branchial appendage of moderate size. Two pairs of feet of moderate size, five-jointed; second pair much the longest, and having the last joint armed with one long and two small curved setæ; first three joints of nearly equal length; fourth and fifth, respectively, about one-half and one third as long as the preceding. Abdomen ending in a short conical process. Copulative organs of the male of complex structure, the basal portion of an irregularly-shaped plate produced laterally into an aliform process, and on the distal margin into a short, strong hook. Female probably viviparous." (Brady and Norman, 31.)

Darwinula improvisa sp. n.

PLATE LXXXI, FIGS. 1-3, 13.

Length of female 0.68 mm. Height 0.27 mm. Width 0.24 mm. Length of male 0.70 mm. Height 0.23 mm.

The right valve is larger than the left and overlaps it on the ventral side. In the female the height is more than one-third of the

length and the width is less than the height. In the male the height is about one-third of the length. The color is yellow, with two green blotches, one on each side, in front of the middle. These patches of pigment are on the animal but show conspicuously through the translucent valves. The female carries her young in the enlarged caudal portion of the valves. These are white and show distinctly through the valves.

Viewed from the side the shell is oblong, depressed in front, broadest caudad of the middle. The two extremities are rounded, the cephalic end is narrow, while the caudal one is broad.

Viewed from above the shell is ovate-acuminate, widest near the caudal extremity. The cephalic extremity is pointed while the caudal is broad and notched where the two unequal valves meet.

The antennules are stout and appear to be composed of only five joints. In this respect as well as in the arrangement of the setæ this member differs from the corresponding member of *D. stevensoni*.

The antennæ are stout and are composed of five joints. The long terminal claws are as long as the combined lengths of the last three joints. The antepenultimate joint bears a conspicuous one-jointed appendage which terminates in one long and one short filament. Here we have another marked difference between this species and *D. stevensoni*.

The mandible bears a three-jointed palp, to the terminal joint of which is appended a lamina bearing several long curved filaments.

The second maxilla bears a leg-like palp. The first foot is stout and five-jointed. The second foot is not bordered by a fringe of hairs. For arrangement of the setæ consult the figures.

The second foot consists of five joints; the terminal claw is longer than that of the first foot. Like the first foot, none of its members are bordered with short hairs. For the arrangement of setæ consult the figures.

The abdomen terminates in a pointed process.

Habitat: The only specimens yet found were collected in a sand bottom reservoir at Atlanta, Georgia, Sept. 1, 1894. This reservoir is about three miles in circumference and is fed by creeks which arise a short distance off at the watershed of the state.

PLATES

AND

EXPLANATIONS

EXPLANATION OF PLATE I.

Limnocalanus macrurus Sars.

FIG.

1. Left foot of the fifth pair in the male.
2. Right foot of the same pair.
3. Foot of the fifth pair in the female.
4. Abdomen.

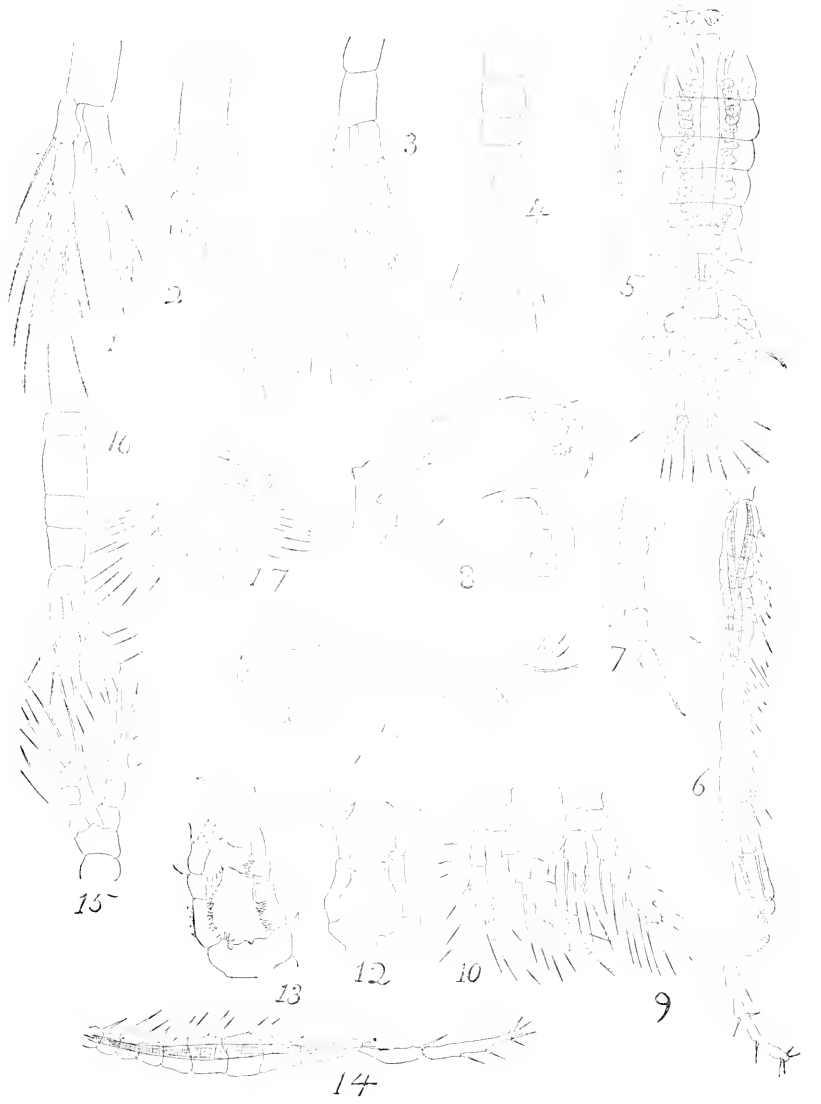
Eurytemora affinis Poppe.

5. Female from above.
6. Right antenna.
7. Fifth foot of female.
8. Feet of fifth pair in the male.
9. First foot.
10. One of the swimming feet.

Pseudodiaptomus pelagicus Herrick.

11. Lateral view of female with ovisac and spermatophore.
12. Fifth feet of female.
13. Fifth feet of male.
14. Portion of right male antenna.
15. One of the swimming feet.
16. Abdomen of male.
17. Antennules.

NOTE.—All details are from females unless specified, and where the parts in the sexes are alike the drawing is always from the female.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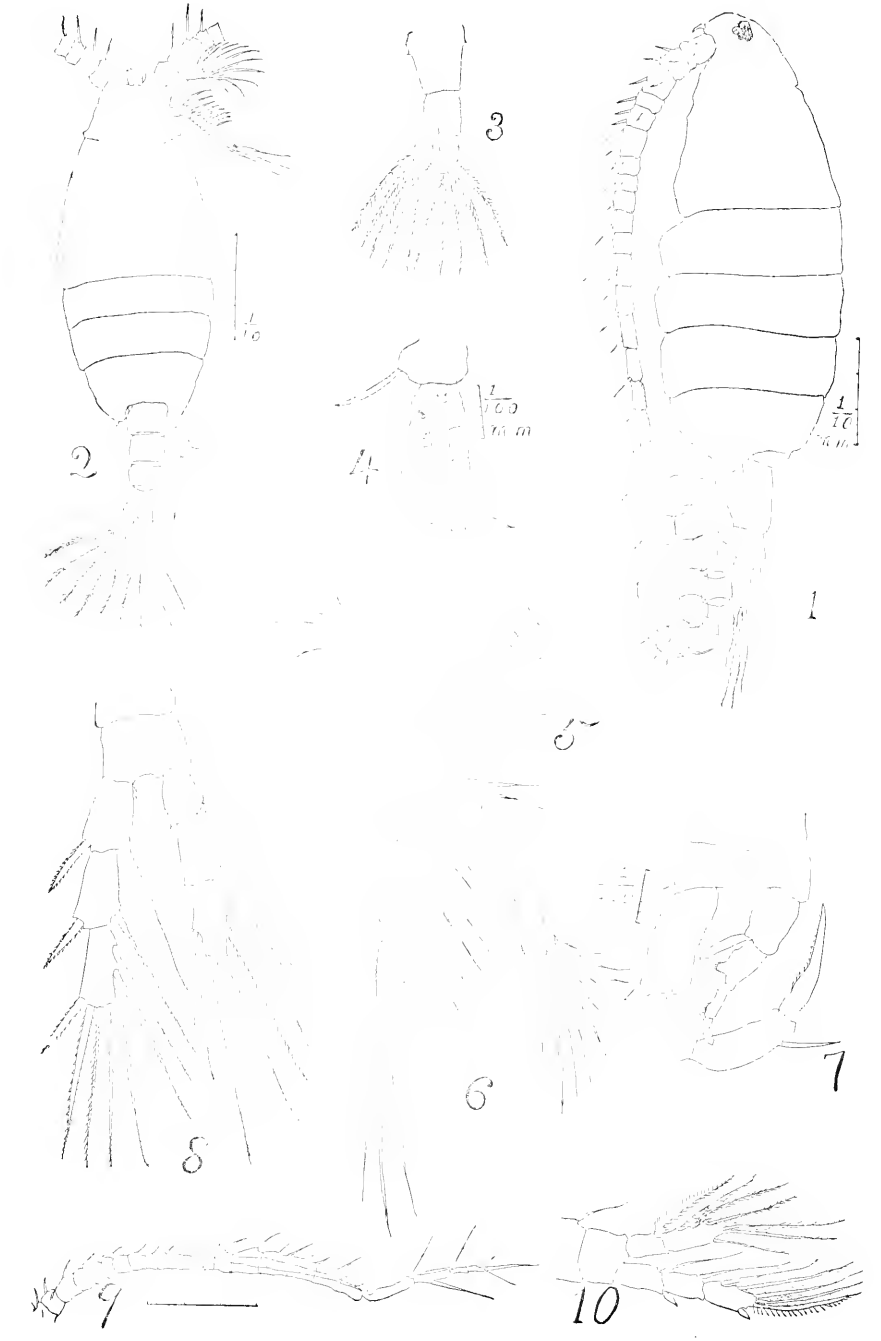
EXPLANATION OF PLATE II.

Diaptomus leptopus Forbes.

FIG.

1. Lateral view of female. Shaded portions purple.
2. Dorsal view of the male. To the same scale.
3. Abdomen of the female from above.
4. Fifth foot of the female.
5. Maxilliped.
6. Antennule.
7. Fifth foot of the male.
8. Fourth foot of the female.
9. Right antenna of the male.
10. First foot.

All the figures are from specimens taken near Minneapolis, Minnesota. Mostly camera lucida drawings copied mechanically.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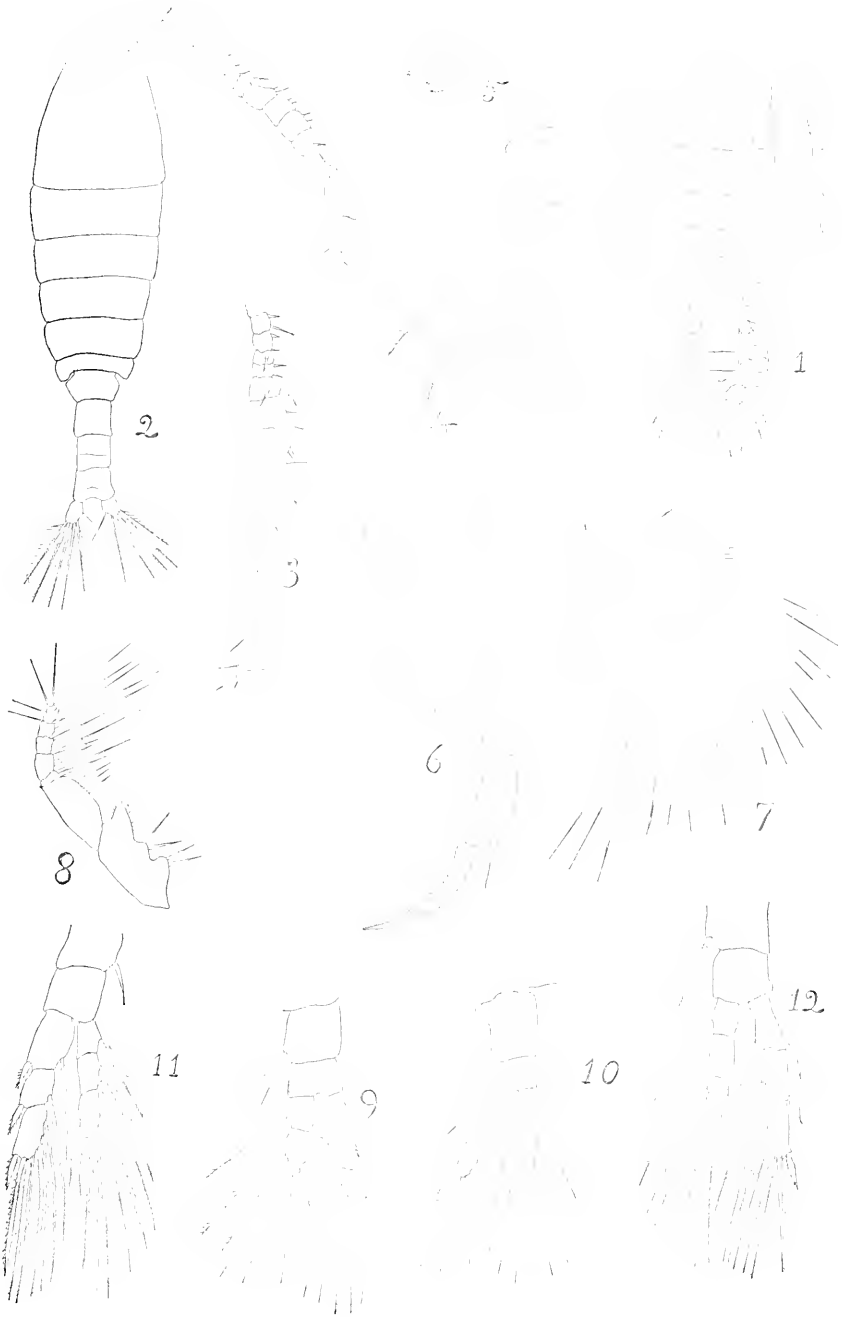
EXPLANATION OF PLATE III.

Diaptomus stagnalis Forbes.

FIG.

1. Female from above.
2. Male from above.
3. Portion of male right antenna—a variant.
4. Stylet of the female.
5. Fifth foot of the female.
6. Fifth feet of the male.
7. Antennule.
8. Maxilliped.
9. First foot of the male.
10. First foot of the female.
11. Third foot of the male.
12. Fourth foot of the male.

All the figures from camera drawings. From specimens secured in Granville, Ohio, in spring.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EXPLANATION OF PLATE IV.

Diaptomus pallidus Herrick.

FIG.

1. Lateral view of preimago (immature) female.
2. Right antenna of male.
3. Fifth feet of the male as they usually appear.
4. Fifth feet of the female. From Minneapolis specimens.
5. Feet of fourth pair.
6. Fifth feet of the male, showing the true nature of the appendages of the left foot. The inner ramus of the left foot is not shown in the figure.

Diaptomus oregonensis Lilljeborg.

7. Right antenna of the male.
8. Fifth feet of the male.
9. Fifth foot of the female.
10. Palpus of the mandible.
11. Left foot of the fifth pair according to Lilljeborg.
12. End of the female antenna.

All but Fig. 11 from specimens from Lake Minnetonka, near Minneapolis, Minnesota.

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EXPLANATION OF PLATE V.

Diaptomus sicilis Forbes.

Fig.

1. Dorsal view of the female.
2. Dorsal view of the male.
3. Right antenna of the male.
4. Fifth foot of the female. A series of fine hairs on the inner aspect of the one-jointed ramus is omitted in the figure.
5. Fifth feet of the male.
6. Antennules.
7. Stylet.

Diaptomus sanguineus Forbes.

8. Fifth foot of the male.
9. Male right antenna. From Granville, Ohio,
10. **Diaptomus pallidus** Herrick. Lateral outline.
11. " **shoshone** Forbes. Fifth feet of male.
12. " **lintoni** Forbes. " " "
13. " **piscinæ** Forbes. " " " The small hairs at the end of the one-jointed ramus of the left leg are omitted in the figure.

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EXPLANATION OF PLATE VI.

Diaptomus albuquerquensis Herrick.

FIG.

1. Fifth feet of the male.
2. Extremity of the right antenna of the male.
3. Fifth foot of the female in one-jointed condition.

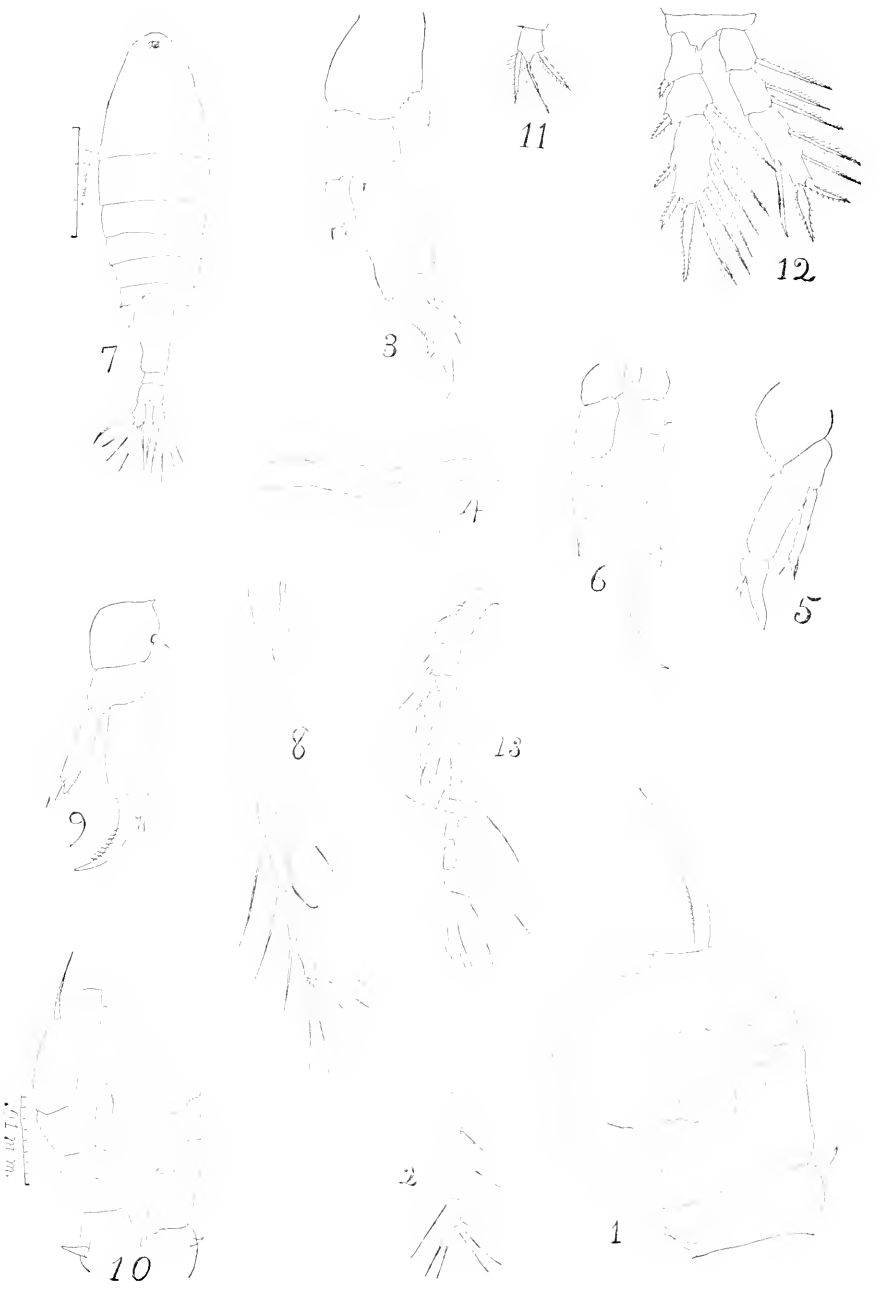
Diaptomus ashlandi Marsh.

4. Extremity of the right antenna of the male.
5. Fifth foot of the female.
6. Fifth feet of the male.

Diaptomus novamexicanus Herrick.

7. Female, from above.
8. Portion of the right antenna of the male. The hyaline plate on the antepenult segment is incorrectly represented as depressed in the middle.
9. Fifth foot of the female.
10. Fifth feet of the male.

11. **Cyclops ater** Herrick. Fifth foot.
12. " **ater** Herrick. Fourth foot.
13. " **capilliferus** Forbes. Antenna.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EXPLANATION OF PLATE VII.

Diaptomus albuquerquensis Herrick.

FIG.

1. Dorsal view of the female. Appendages omitted. Camera.
2. Lateral view with antenna and egg sac. Camera.
3. Dorsal view of the abdomen. Camera.
4. One of the feet of the fifth pair in the female. Camera.
5. Second antenna.
6. Jaw and its palp.
7. Outer maxilliped.
8. Foot of the first pair.
9. Foot of the second pair.
10. Extremity of the male right antenna.
11. The fifth feet of the male. Camera.

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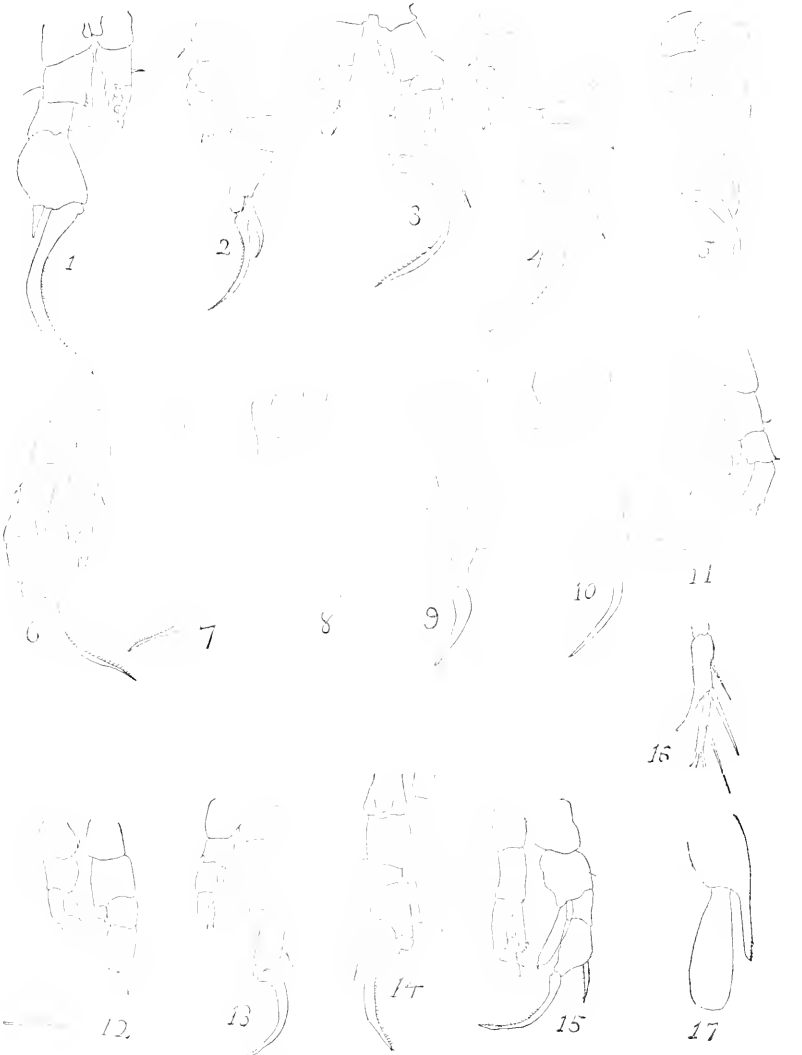
EXPLANATION OF PLATE VIII.

FIG.

1. **Diaptomus gibber** Poppe. Fifth foot of male.
2. " **roubaui** Richard. Fifth foot of male.
3. " **salinus** Daday. Fifth foot of male.
4. " **wierzejskii** Richard. Fifth foot of male.
5. " **richardi** Schmeil. Fifth foot of male.
6. " **incongruens** Poppe. Fifth foot of male.
7. " **lobatus** Lilljeborg. Fifth foot of male.
8. " **mirus** Lilljeborg. Fifth foot of male.
9. " **minutus** Lilljeborg. Fifth foot of male.
10. " **siciloides** Lilljeborg. Fifth foot of male.
11. " **theeli** Lilljeborg. Fifth foot of male.
12. " **franciscanus** Lilljeborg. Fifth foot of male.
13. " **signicaudatus** Lilljeborg. Fifth foot of male.
14. " **serricornis** Lilljeborg. Fifth foot of male.
15. " **laciniatus** Lilljeborg. Fifth foot of male.
16. " **franciscanus** Lilljeborg. Antepenultimate joint of right male antenna.
17. " **trybomi** Lilljeborg. Antepenultimate joint of right male antenna.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EXPLANATION OF PLATE IX.

FIG.

1. **Diaptomus gracilis** Sars. Fifth foot of male.
2. " **amblyodon** Marenzeller. Fifth foot of male.
3. " **oregonensis** Lilljeborg. Fifth foot of male.
4. " **trybomi** Lilljeborg. Fift foot of male.
5. " **castor** Jurine. Fifth foot of male.
6. " **lilljeborgi** De Guerne and Richard. Fifth foot of male.
7. " **cœruleus** Fischer. Fifth foot of male.
8. " **glacialis** Lilljeborg. Fifth foot of male.
9. " **leptopus** Forbes. Fifth foot of male.
10. " **signicaudatus** Lilljeborg. Abdomen.
11. " **roubaui** Richard. Abdomen.
12. " **serricornis** Lilljeborg. Antepenult joint of right male antenna.
13. " **wierzejskii** Richard. Antepenult joint of right male antenna.

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EXPLANATION OF PLATE X.

Fig.

1. **Diaptomus lumholtzi** Sars. Fifth foot of male.
2. " **baccillifer** Koebel. Fifth foot of male.
3. " **pectinicornis** Wierzejski. Fifth foot of male.
4. " **denticornis** Wierzejski. Fifth foot of male.
5. " **orientalis** Brady. Fifth foot of male.
6. " **zachariasi** Poppe. Fifth foot of male.
7. " **asiaticus** Uljanin. Fifth foot of male.
8. " **tatricus** Wierzejski. Fifth foot of male.
9. " **tyrrelli** Poppe. Fifth foot of male.
10. " **affinis** Uljanin. Fifth foot of male.
11. " **eiseni** Lilljeborg. Fifth foot of male.
12. " **laciniatus** Lilljeborg. Abdomen.
13. " **trybomi** Lilljeborg. Abdomen.
14. **Heterocope saliens** Lilljeborg. Fifth foot of male.
15. " **borealis** Fischer. Fifth foot of male.
16. **Broteas falcifer** Loven. Third maxilliped.

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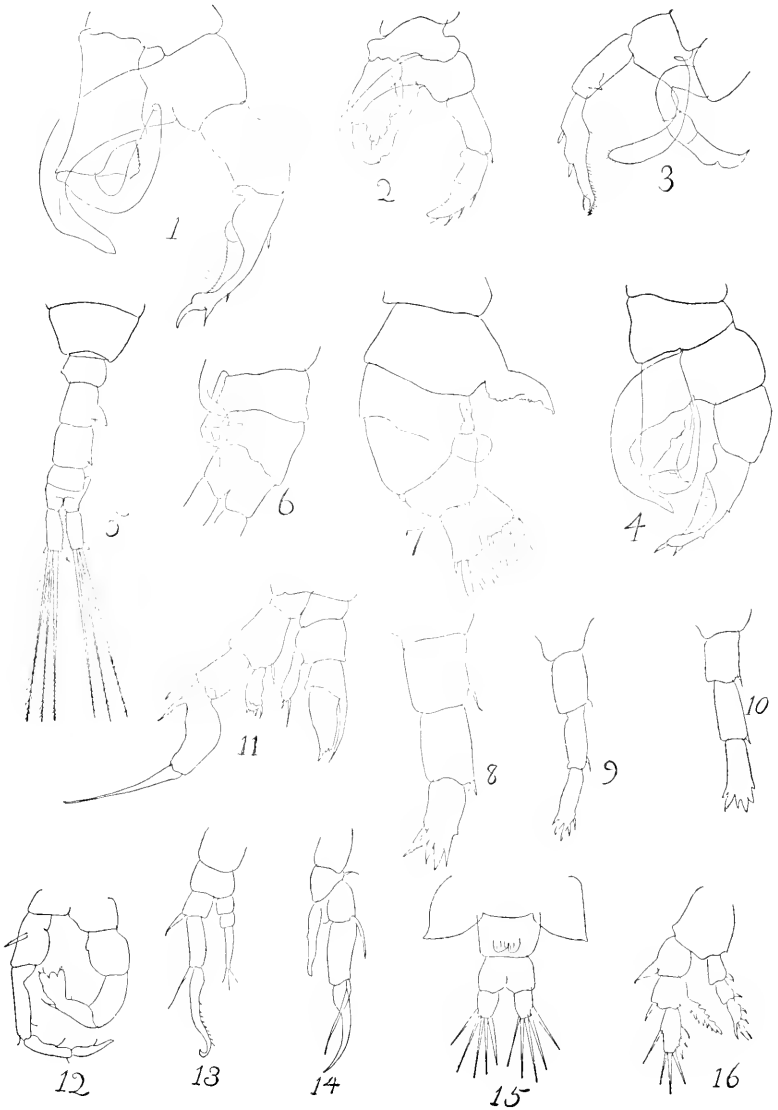
EXPLANATION OF PLATE XI.

FIG.

1. **Epischura nevadensis** Lilljeborg. Fifth feet of male.
2. " **nordenskiœldi** Lilljeborg. Fifth feet of male.
3. **Heterocope appendiculata** Sars. Fifth feet of male.
4. **Epischura nevadensis** var. **columbiæ** Forbes. Fifth feet of male.
5. " **nordenskiœldi** Lilljeborg. Abdomen.
6. " **nevadensis** Lilljeborg. Abdomen.
7. " **columbiæ** Forbes. Abdomen.
8. " **nevadensis** Lilljeborg. Fifth foot of female.
9. " **nordenskiœldi** Lilljeborg. Fifth foot of female.
10. " **nevadensis** var. **columbiæ** Forbes. Fifth foot of female.
11. **Poppella guernei** Richard. Fifth feet of male.
12. **Eurytemora velox** Lilljeborg. Fifth feet of male.
13. **Bœckella brasiliensis** Lubbock. Right fifth foot of male.
14. " **triarticulata** Lubbock. Right fifth foot of male.
15. **Centropages brevicaudatus** Brady. Abdomen.
16. " **brevicaudatus** Brady. Fifth feet of female.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EXPLANATION OF PLATE XII.

Osphranticum labronectum (Potamoichetor).

FIG.

1. Male.
2. Antennule.
3. Maxilliped.
4. Fifth feet of the male.
5. Palp of the mandible.
6. End of the abdomen.
7. Feet of the first pair.
8. Eye.

Cyclops ater.

9. Female.
10. Abdomen.
11. Maxilliped.
12. Antenna.

13. **Osphranticum labronectum.** Maxilla.
14. " **labronectum.** Antenna.

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EXPLANATION OF PLATE XIII.

Alonella pulchella.

FIG.

1. Female.
2. Reticulations.
3. Post-abdomen.

4. **Alona modesta.** Male.

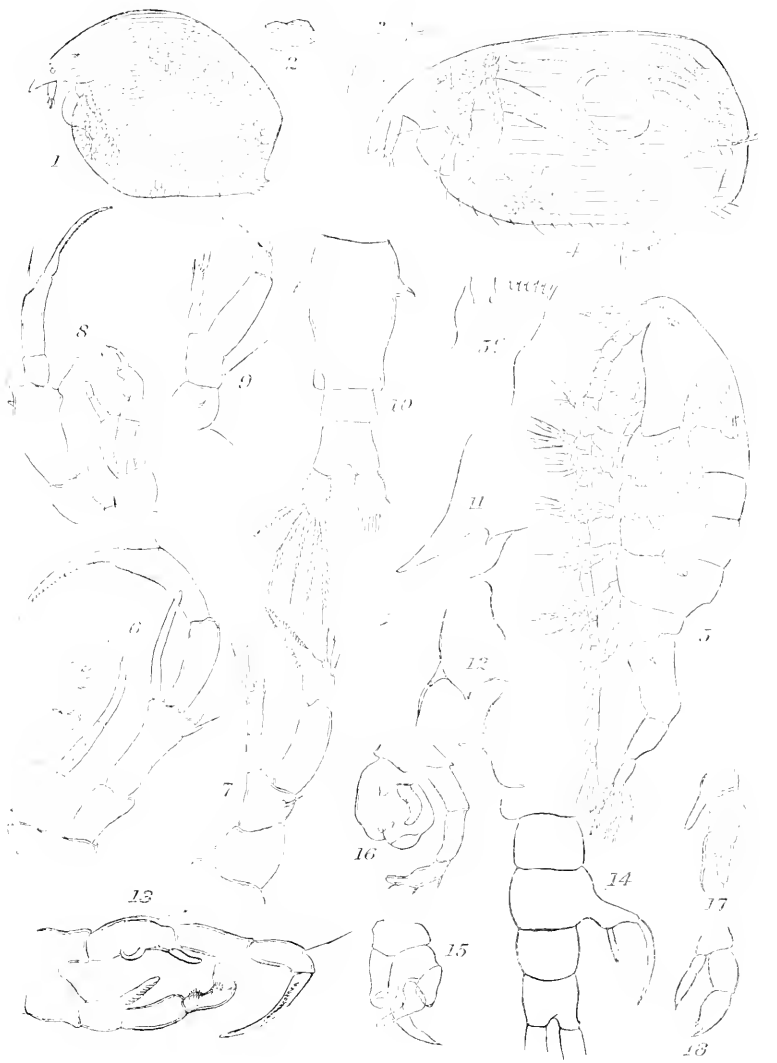
Diaptomus similis.

5. Female
5*a*. Jaw.
6. Fifth foot of the male.
7. Fifth foot of the female.

Diaptomus minnetonka.

8. Fifth foot of the male.
9. Fifth foot of the female.
10. Abdomen of the female.

11. **Diaptomus stagnalis.** Margin of the last thoracic segment.
12. " **sanguineus.** Margin of the last thoracic segment.
13. " **stagnalis.** Fifth foot of the male.
14. **Epischura fluviatilis.** Abdomen of the male.
15. " **lacustris.** Fifth feet of the male.
16. " **fluviatilis.** Fifth feet of the male.
17. **Diaptomus pallidus.** Inner ramus of the fifth feet of the male.
18. " **sicilis.** Inner ramus of the fifth feet of the male.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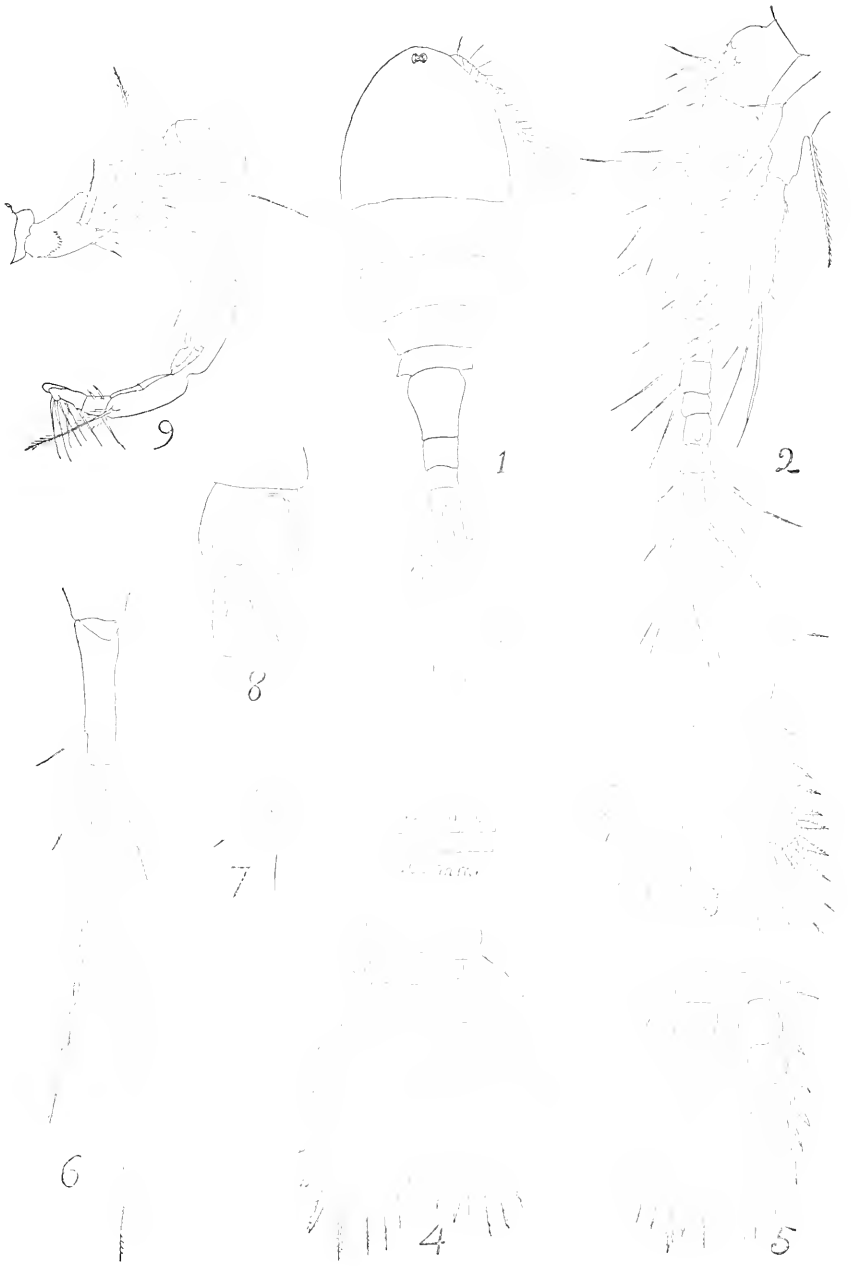
EXPLANATION OF PLATE XIV.

Cyclops viridis var. **americanus** Marsh.

FIG.

1. Female from above.
2. Antenna and antennule.
3. Foot of the first pair.
4. Foot of the third pair.
5. Foot of the fourth pair.
6. Caudal stylet.
7. Fifth foot.
8. Sixth foot of the male.
9. Antenna of the male.

Specimens from Albuquerque, New Mexico.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EXPLANATION OF PLATE XV.

Cyclops signatus var. **coronatus.**

FIG.

1. Outline from above of a mature female.
2. Outline of a male.
3. Fifth foot.
4. One of the fourth pair of feet.

Cyclops signatus var. **tenuicornis.**

5. Tip of the antenna of the female.
6. Fifth foot.
7. Stylet of the female.

Cyclops serrulatus.

8. Foot of the second pair.
9. Foot of the fourth pair.
10. Fifth foot.
11. Stylet of the female. Type.

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EXPLANATION OF PLATE XVI.

Cyclops leuckarti Sars.

Fig.

1. Camera outline of body seen from above.
2. Antenna. Camera.
3. Caudal stylet. Camera.
4. Terminal segments of antenna to show armature.
5. Fifth foot. Camera.
6. Outer maxilliped. Camera.
7. Inner maxilliped. Camera.
8. Foot of first pair. Camera.
9. Foot of second pair.
10. Foot of fourth pair. Camera.
11. Opening of the spermatheca.

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EXPLANATION OF PLATE XVII.

Cyclops phaleratus.

FIG.

1. Outline of the male from above.
2. Stylet of the male.
3. Fifth and sixth feet of the male.
4. Antenna of the male.
5. Antenna of the female.
6. Fifth foot of the female.
7. Fourth foot.

Cyclops fimbriatus.

8. Stylet.
9. Antenna of the female.

Cyclops languidus.

10. Antenna of the female.
11. Fifth foot.

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EXPLANATION OF PLATE XVIII.

Cyclops leuckarti.

Fig.

1. Slender form.
a. Abdomen.
b. Labrum.
c. Antenna.
d. Fifth foot.
e. Feet of fourth pair.
f. Feet of second pair.
g. Feet of first pair.
h. Antennule.
. Maxilliped.
j. Mandible.

Cyclops phaleratus.

2. Ventral view of female.
2*a*. Part of the abdomen of the male with sixth foot.
2*b*. Antenna.
2*c*. Labrum.
2*d*. Pair of feet.

Cyclops bicolor.

3. Lateral view.
3*a*. Abdomen.
3*b*. Foot of the fourth pair.
3*c*. Antenna.
3*d*. Labrum.
3*e*. Receptaculum.

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Fig. 3.

EXPLANATION OF PLATE XIX.

FIG.

1. **Cyclops phaleratus.** Female.

Cyclops serrulatus.

2. Male.
3. Under surface of abdomen.
4. Last joints of antenna of the female.
5. First foot. The spine of the distal segment of outer ramus is incorrectly shown as curved.

Cyclops diaphanus.

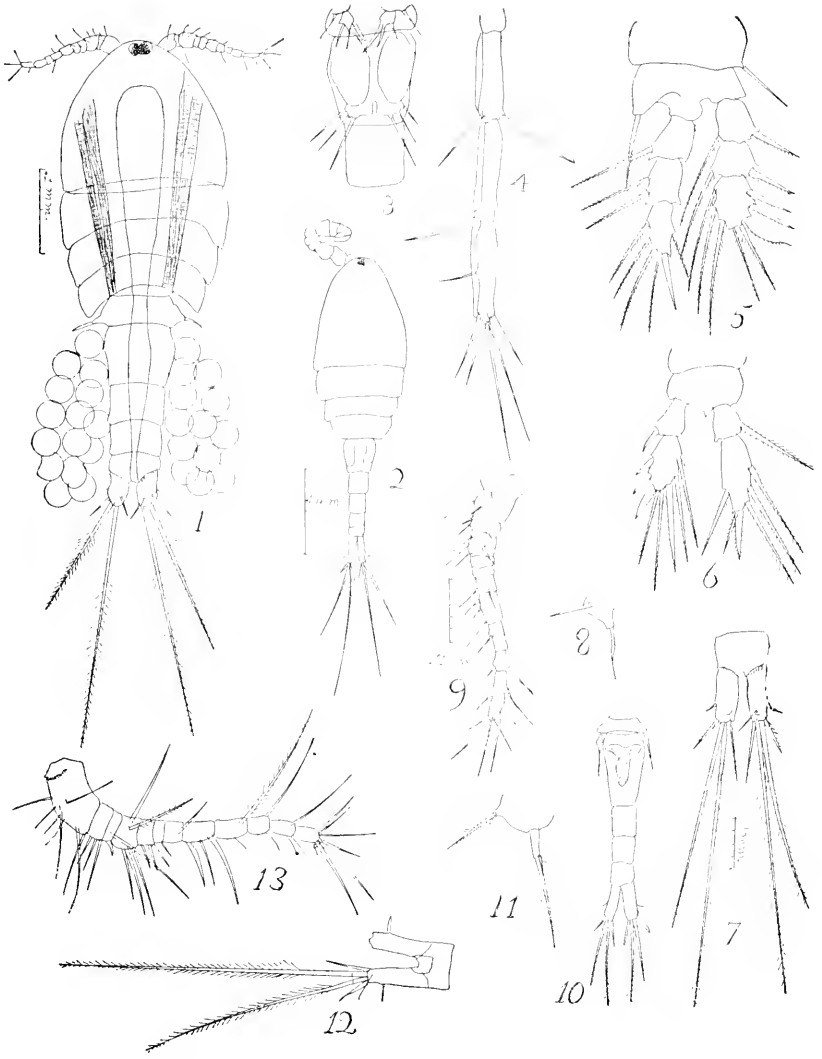
6. Fourth foot.
7. Stylets.
8. Fifth foot.
9. Antenna.

Cyclops gracilis.

10. Abdomen.
11. Fifth foot.

Cyclops varicans.

12. Stylets.
13. Antenna.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EXPLANATION OF PLATE XX.

Cyclops signatus var. **tenuicornis.**

FIG.

1. Female.
2. Mandible.
3. Maxillæ.
4. Stylet.
5. Fifth foot.
6. Maxillipedes.
7. Antenna.

Cyclops signatus.

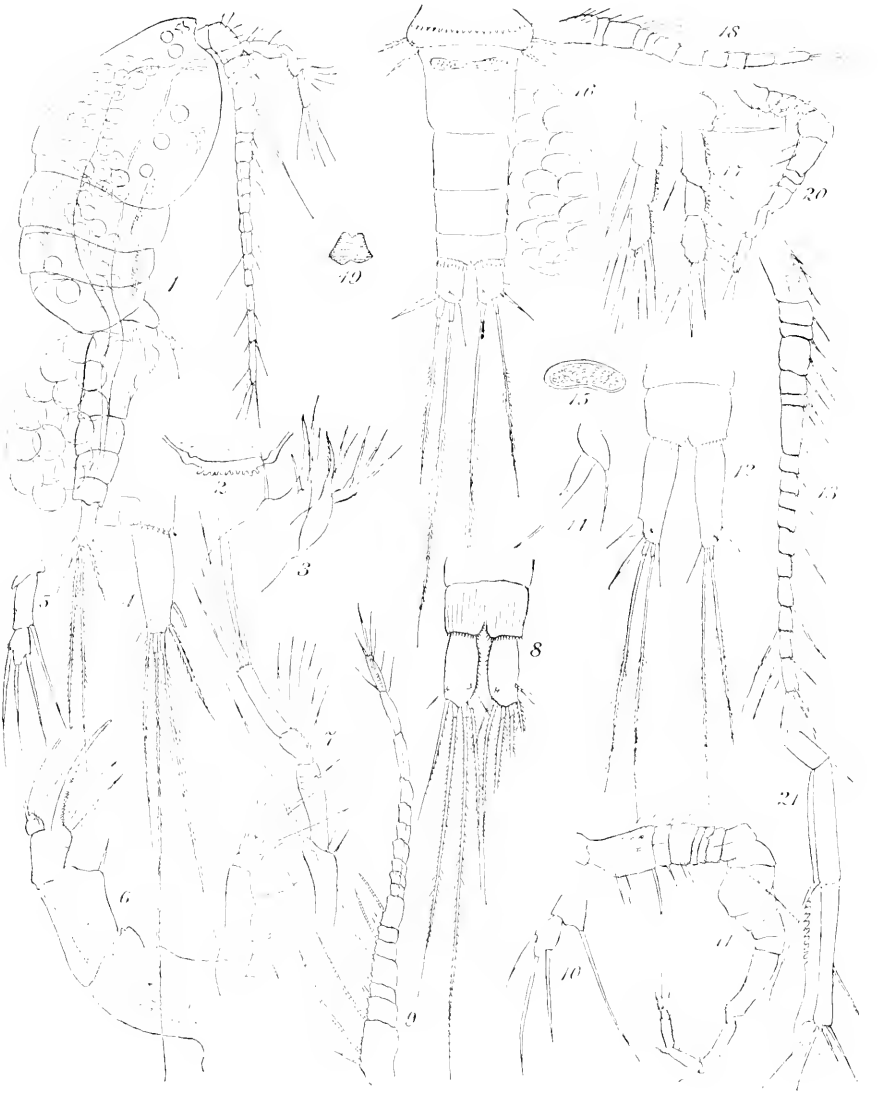
8. Abdomen.
9. Antenna.
10. Fifth foot.
11. Male antenna.

Cyclops parcus.

12. Abdomen.
13. Antenna.
14. Fifth foot.
15. Receptaculum seminis.

Cyclops adolescens

16. Abdomen.
17. Foot.
18. Antenna of female.
19. Eye.
20. Antenna of male.
21. **Cyclops signatus.** End of antenna.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EXPLANATION OF PLATE XXI.

Cyclops modestus.

Fig.

1. Side view.
2. End of the abdomen.
3. Outer ramus of first foot.
4. Outer ramus of second foot.
5. Fifth foot.

Cyclops phaleratus.

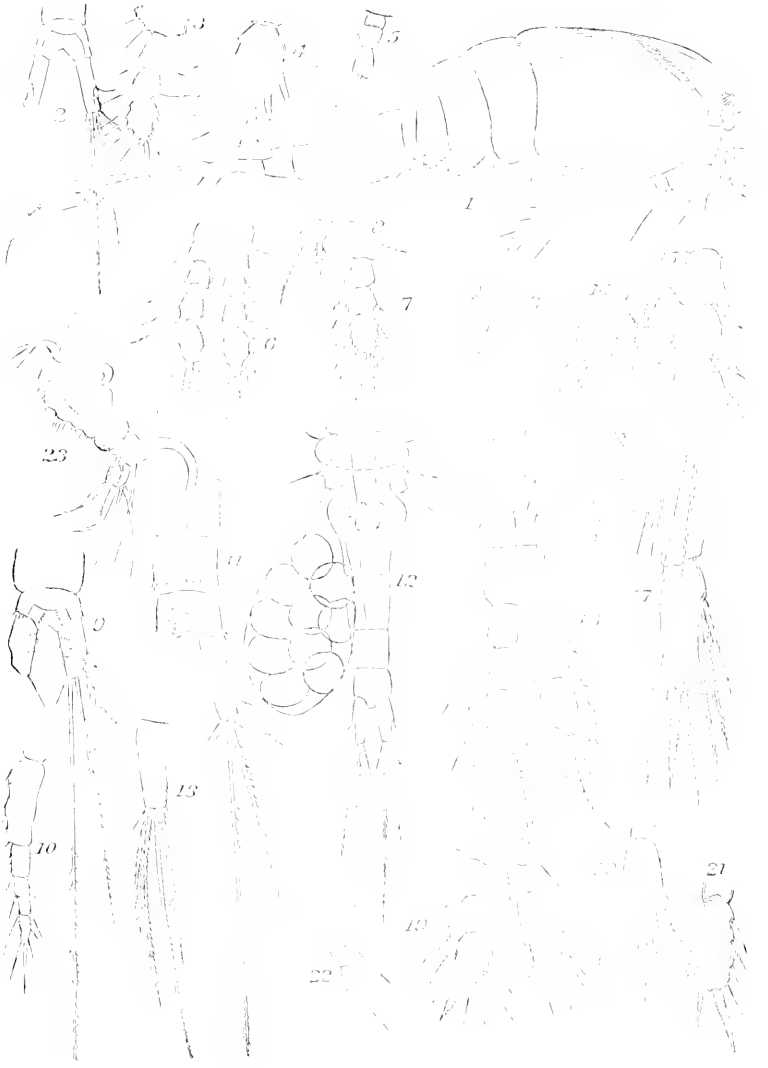
6. Fourth foot.
7. Outer ramus of first foot.
8. Fifth foot.
9. Caudal stylets.
10. Antenna of young, otherwise perfect.

11. **Cyclops fimbriatus.** End of abdomen.
12. " **bicolor.** Abdomen.

Cyclops ater.

13. Inner ramus of first foot.
14. Outer ramus of first foot.
15. Outer ramus of fourth foot.

16. **Cyclops signatus.** Fourth foot.
17. " **ater.** Inner ramus of fourth foot.
18. " **ater.** Stylet.
19. " **sp.?** First foot.
20-21. " **sp.?** Terminal segments of fourth foot.
22. " **parcus.** Fifth foot.
23. **Chydorus globosus.** First foot of male.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EXPLANATION OF PLATE XXII.

Canthocamptus minnesotensis.

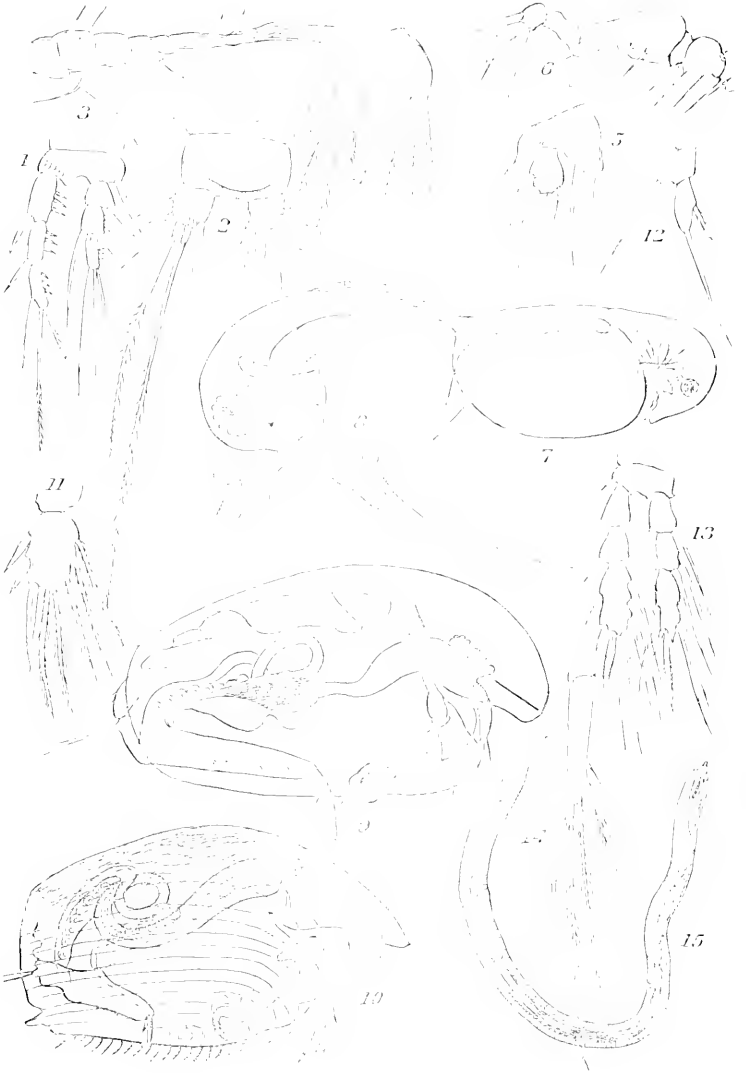
FIG.

1. First foot.
2. Stylets.
3. Antenna of female.
4. Fifth foot of female.
5. Fifth foot of male.
6. Antenna of male.
7. **Daphnia hyalina (D. galeata).** Young.
8. " " " Male.
9. **Camptocercus leucocephalus.** Male.
10. **Alonella excisa.** Male.

Cyclops insignis.

11. Outer ramus of the first foot.
12. Fifth foot.
13. Fourth foot.
14. Stylet.

15. Worm parasitic in arterial sinus of **Daphnia schaefferi.**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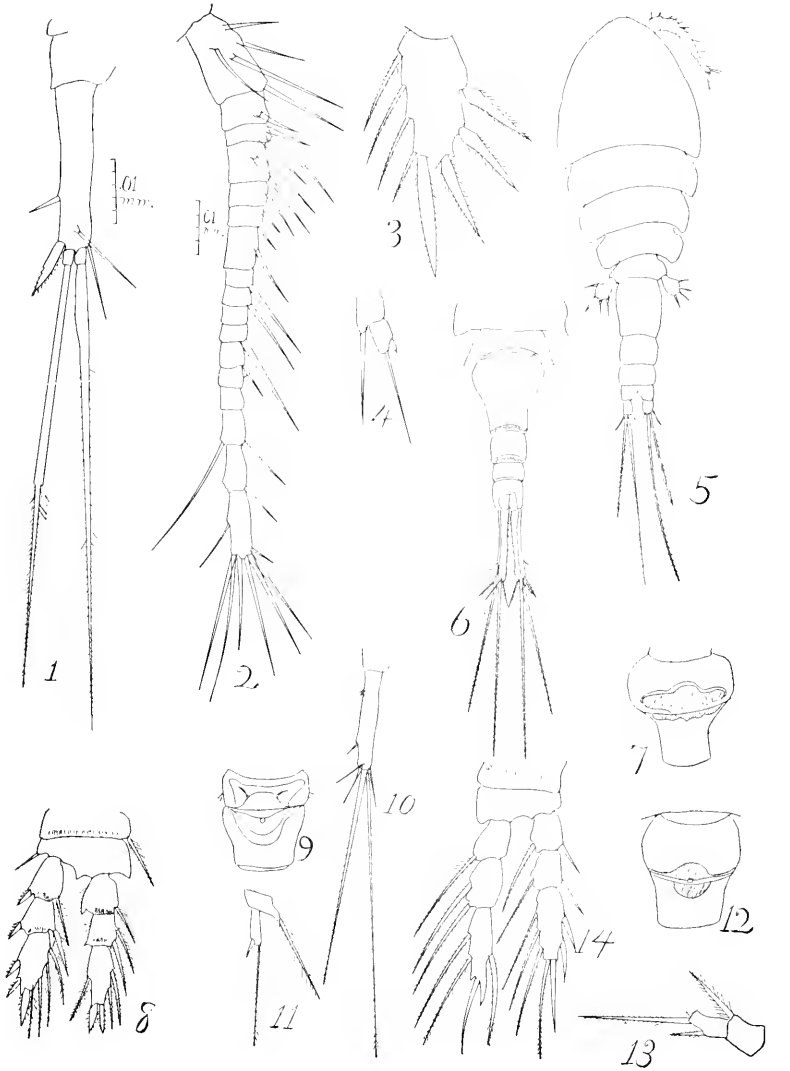
EXPLANATION OF PLATE XXIII.

Cyclops brevispinosus.

Fig.

1. Stylet.
2. Antenna.
3. Outer ramus of fourth foot, terminal segment.
4. Fifth foot.

5. **Cyclops æquoreus.** After Brady.
6. " **insignis.** Abdomen.
7. " **insignis.** Receptaculum, after Schmeil.
8. " **parcus.** Fourth foot.
9. " **bisetosus.** Receptaculum, after Schmeil.
10. " **bisetosus.** Stylet.
11. " **bisetosus.** Fifth foot.
12. " **strenuus.** Receptaculum, after Schmeil.
13. " **strenuus.** Fifth foot.
14. " **abyssorum.** Fourth foot.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EXPLANATION OF PLATE XXIV.

FIG.

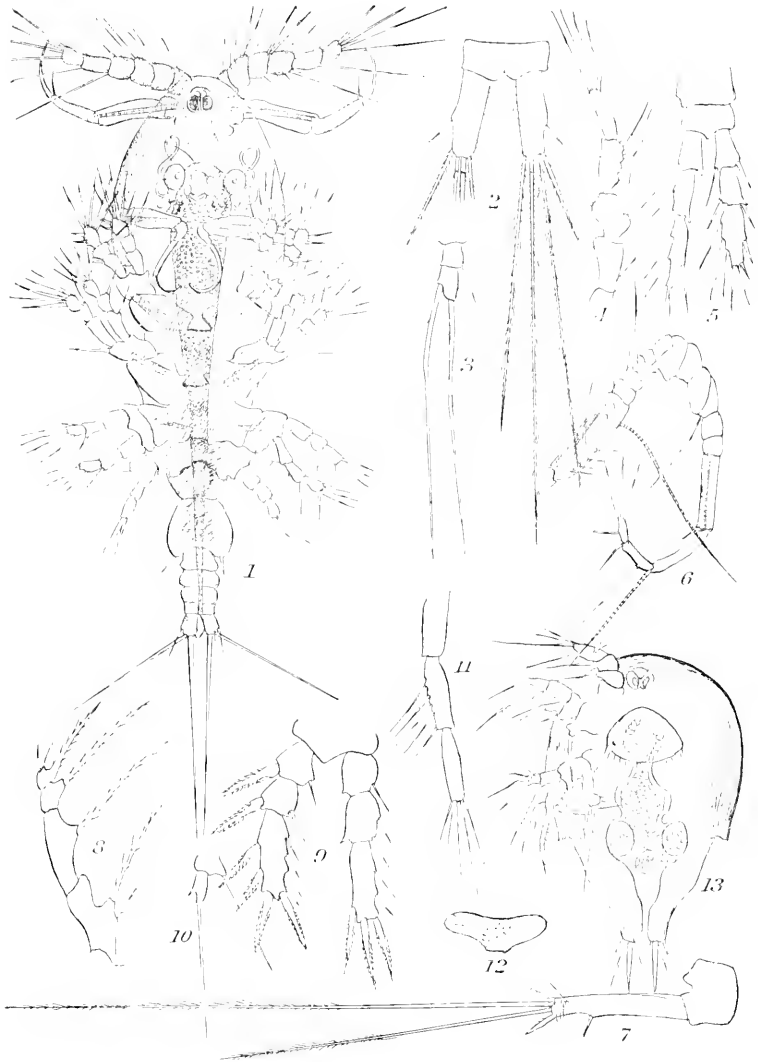
1. **Ergasilus depressus.** Male.

Cyclops leuckarti, deep-water variety, = **C. tenuissimus.**

2. Stylets.
3. Fifth foot.
4. Antennule.
5. Fourth feet.
6. Antenna of male.

Cyclops brevispinosus.

7. Stylet.
8. Inner maxilliped.
9. Swimming foot.
10. Fifth foot.
11. Antennule.
12. Opening of receptaculum.
13. **Cyclops sp.?** Nauplius.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EXPLANATION OF PLATE XXV.

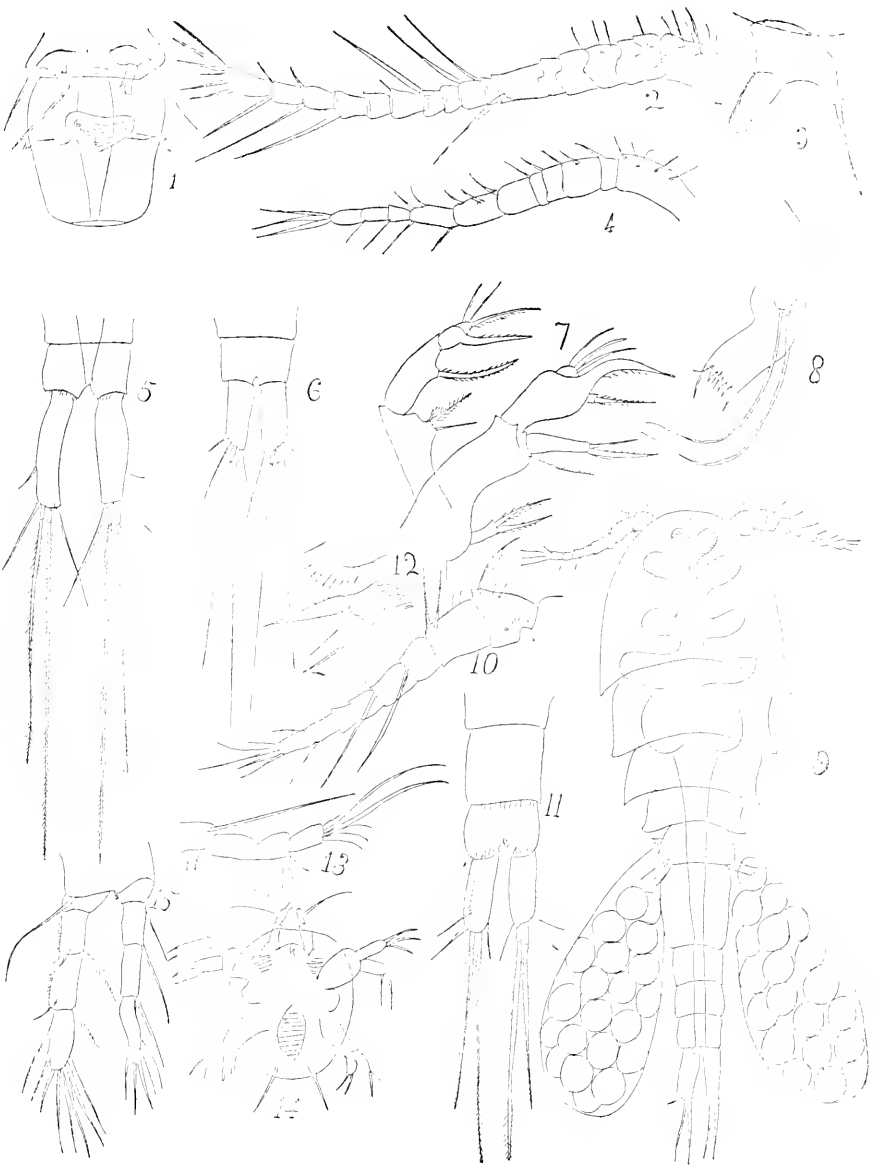
Cyclops ingens.

FIG.

1. First segment of abdomen of female.
2. Antenna.
3. Fifth foot.
4. Antenna of young male.
5. Stylets of mature female.
6. Stylets of young male.
7. Maxilliped.
8. Mandible.

Cyclops fimbriatus.

9. Female from above.
10. Antenna.
11. Terminal portion of abdomen.
12. Female fifth foot.
13. Second antenna.
14. Nauplius form.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EXPLANATION OF PLATE XXVI.

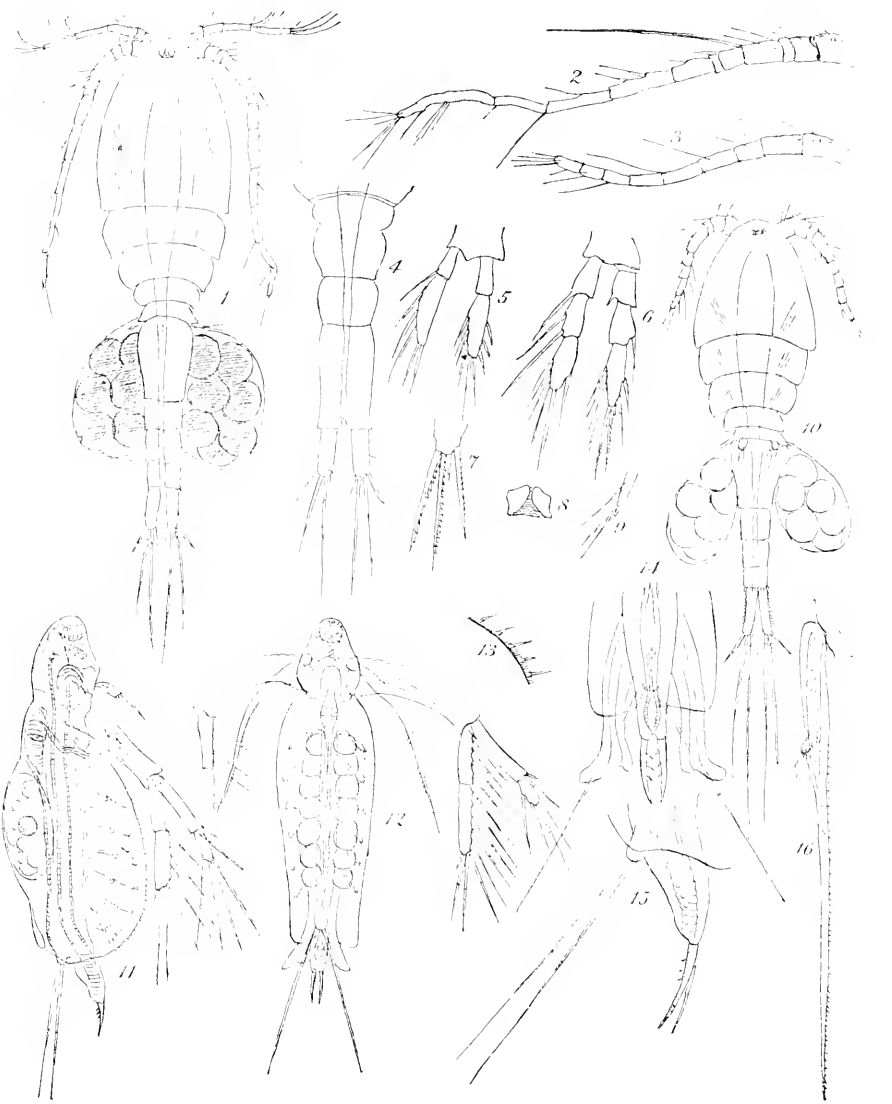
Cyclops fluviatilis.

FIG.

1. Female from above.
2. Antenna.
3. Antenna of young.
4. Abdomen of young.
5. Foot of young.
6. Foot of adult.
7. Fifth foot.
8. Eye.
9. ? (Should have been cut out.)
10. **Cyclops serrulatus.** Young from above.

Daphnella brachyura.

11. Female. Lateral view.
12. Male.
13. Edge of valves.
14. Abdomen of male.
15. Abdomen of female.
16. Antenna of male.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EXPLANATION OF PLATE XXVII.

Daphnia kalbergensis.

Fig.

1. Of moderate size.
2. Antennule of male.
3. Head of variety.
4. **Cyclops pulchellus (thomasi).** Fourth foot.
5. " **pulchellus (thomasi).** Outer ramus of first foot.
6. **Daphnia hyalina (D. galeata).** Typical form.
7. **Cyclops thomasi.** Fifth foo .
8. " **thomasi.** Stylet.
9. **Cyclops (insectus?).** Fourth foot.
10. **Bythotrephes longimanus.** Female.
11. A curious large protozoan; *a.* infundibulum frame work; *b.* pulsating vacuole; *c.* nucleus; *d.* food and digested matter; *e.* protective rods; 11*a.* spicules of the infundibulum.

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EXPLANATION OF PLATE XXVIII.

Cyclops capilliferus Forbes.

FIG.

1. Female.
2. Leg of the fourth pair. The terminal spine of the outer ramus is represented too broad.
3. Leg of first pair.
4. Fifth foot.

Cyclops pulchellus ("**thomasi**").

5. Leg of first pair.
6. Leg of second pair.
7. Leg of fourth pair.
8. Fifth foot.

All the figures are copied from Forbes.

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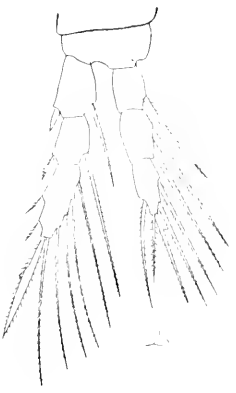
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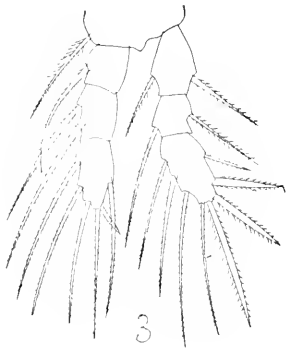
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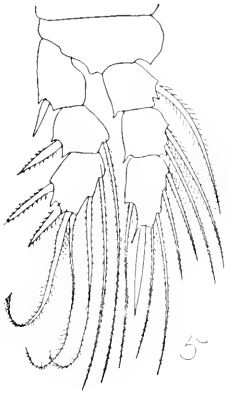
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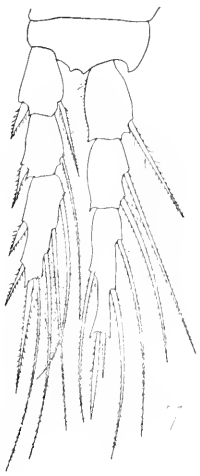
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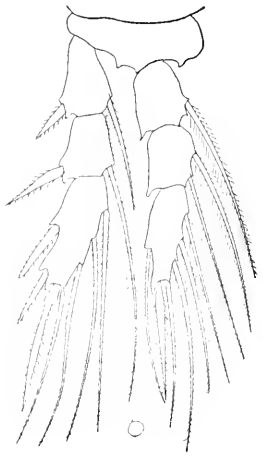
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EXPLANATION OF PLATE XXIX.

Canthocamptus illinoisensis.

Fig.

1. Antenna of female.
2. Fifth foot of female.
3. Antennule.
4. First foot.
5. Caudal stylet.

Canthocamptus northumbricus var. americanus.

6. Fifth foot of female.
7. Antenna of female.
8. Maxilliped.
9. Caudal stylet.
10. Antenna of male.
11. First foot.
12. Fourth foot.
13. Fifth foot of male.
14. Frontal area.
15. **Canthocamptus tennicaudis.** Stylets.
16. " **tennicaudis.** Fifth foot of female.

Cyclops serrulatus.

17. Fifth foot.
18. Fourth foot.
19. Outer ramus of first foot.

Canthocamptus northumbricus.

20. Inner ramus of third male foot.
21. Beak.
22. Maxilla.

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EXPLANATION OF PLATE XXX.

FIG.

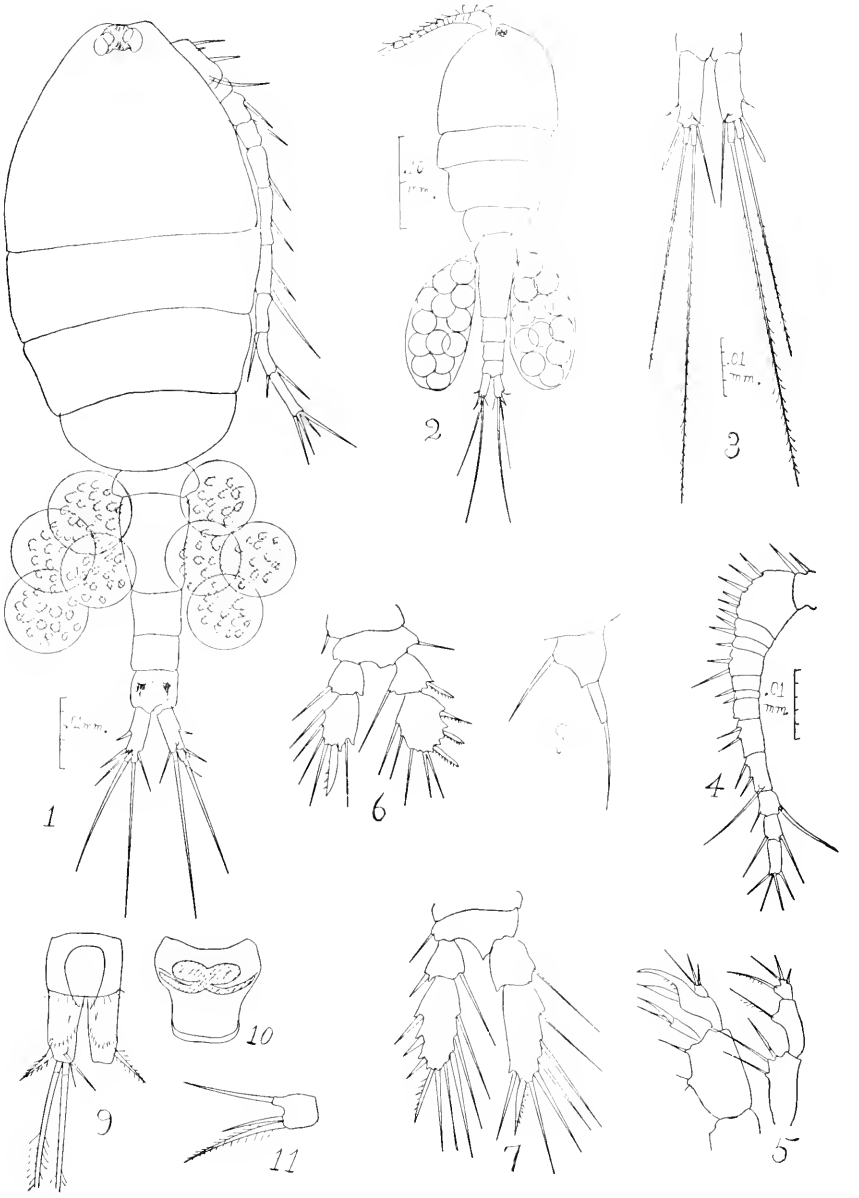
1. **Cyclops fluviatilis** Herrick. Immature female.

Cyclops varicans Sars.

2. Female from above.
3. Caudal stylets.
4. Antenna of female.
5. Maxillipedes.
6. Feet of first pair.
7. Feet of fourth pair.
8. Fifth foot.

Cyclops affinis Sars.

9. Caudal stylets, after Schmeil.
10. Receptaculum.
11. Fifth foot.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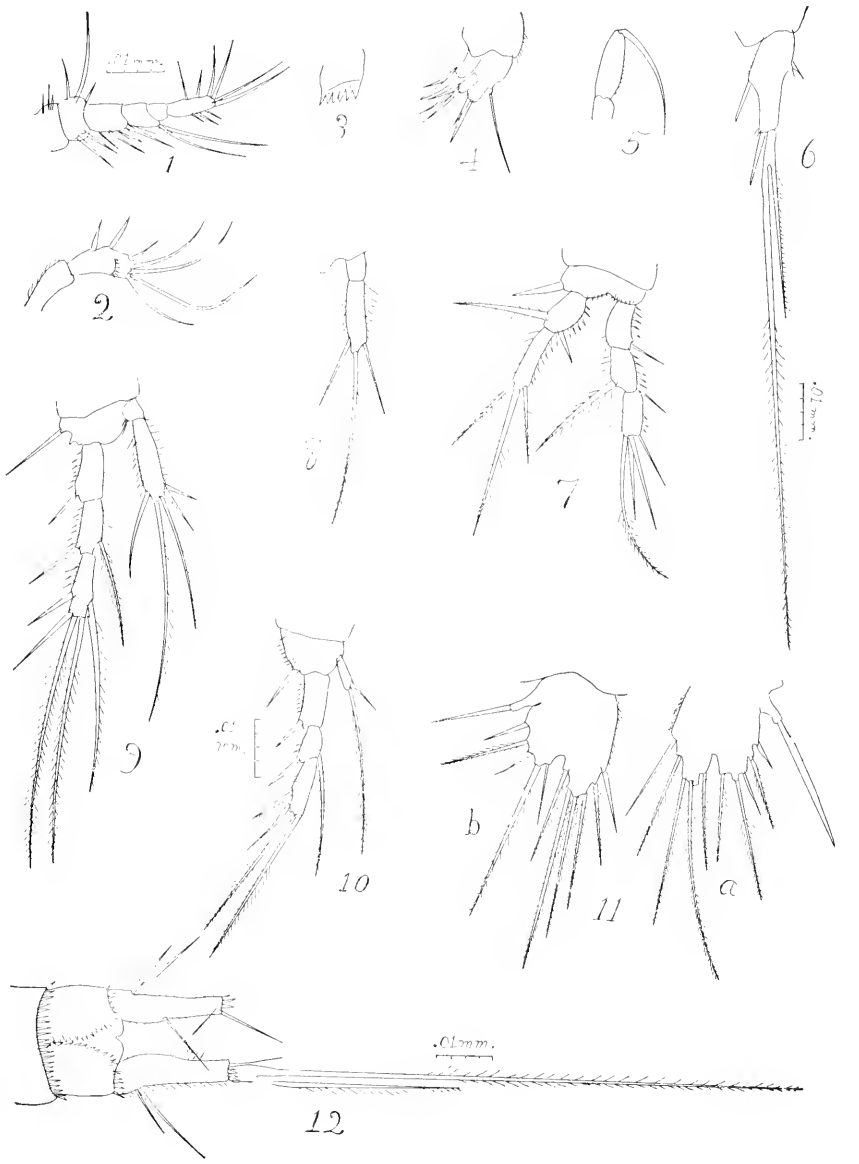
EXPLANATION OF PLATE XXXI.

Marshia albuquerquensis Herrick.

FIG.

1. Antenna of female.
2. Antennule.
3. End of mandible.
4. Anterior maxilliped.
5. Posterior maxilliped.
6. Caudal stylet of female.
7. First foot of female.
8. Outer ramus of second foot.
9. Third foot.
10. Fourth foot.
11. Fifth foot, (*a*) variety, (*b*) type.
12. Caudal stylet of male. The union of the two setæ is imperfectly figured. They form a U-shaped symmetrical union.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EXPLANATION OF PLATE XXXII.

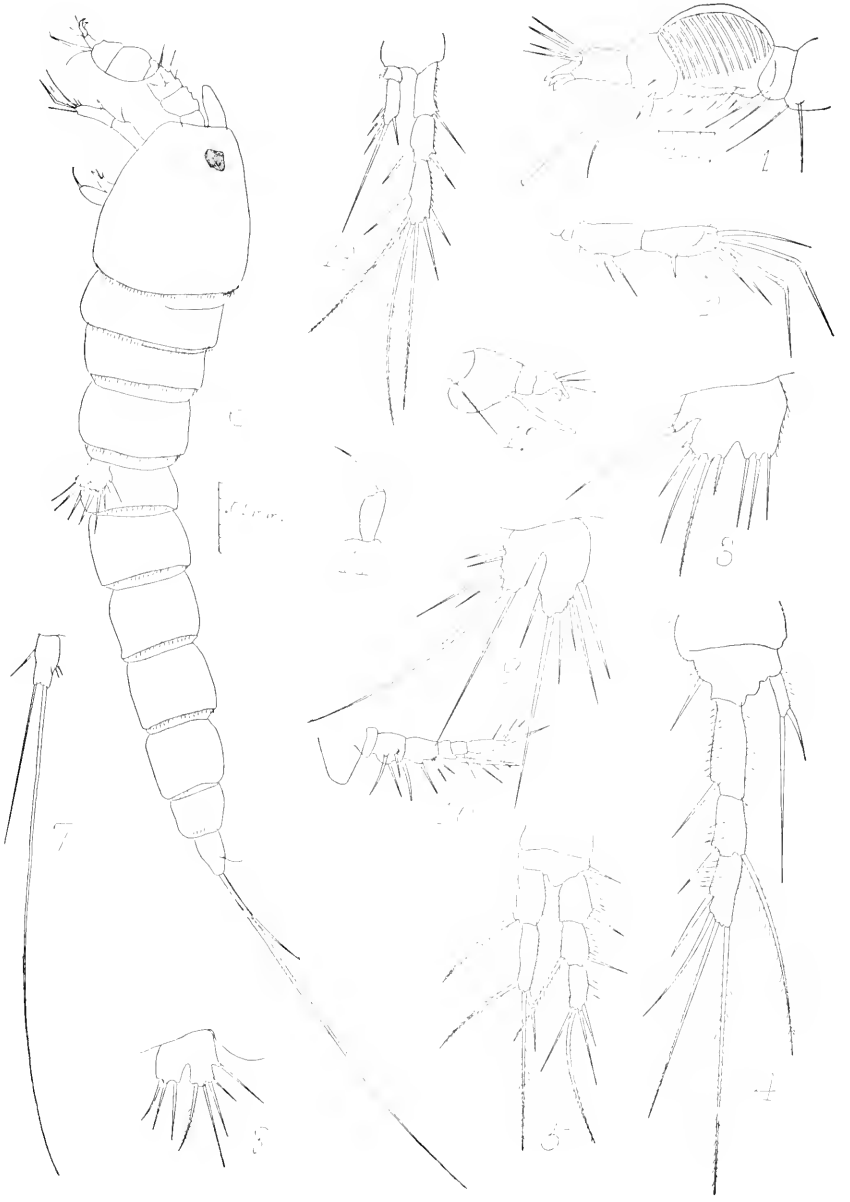
Marshia albuquerquensis.

FIG.

1. Antenna of male.
2. Antennule.
3. Fifth foot of male.
4. Fourth foot of male.
5. First foot of male.

Marshia brevicaudata Herrick.

6. Male.
7. Caudal stylet of male
8. Fifth foot of male.
9. Fifth foot of female.
10. Antenna of female.
11. Posterior maxilliped.
12. Antenna of male.
13. Second foot.



EXPLANATION OF PLATE XXXIII.

FIG.

1. **Cyclops signatus** var. **tennicornis.** Caudal stylet. A case where the inner aspect is ciliate.
2. Fourth foot of same.

Canthocamptus northumbricus var. **americanus.**

3. Caudal stylet.
4. Maxilliped.
5. Fifth foot.

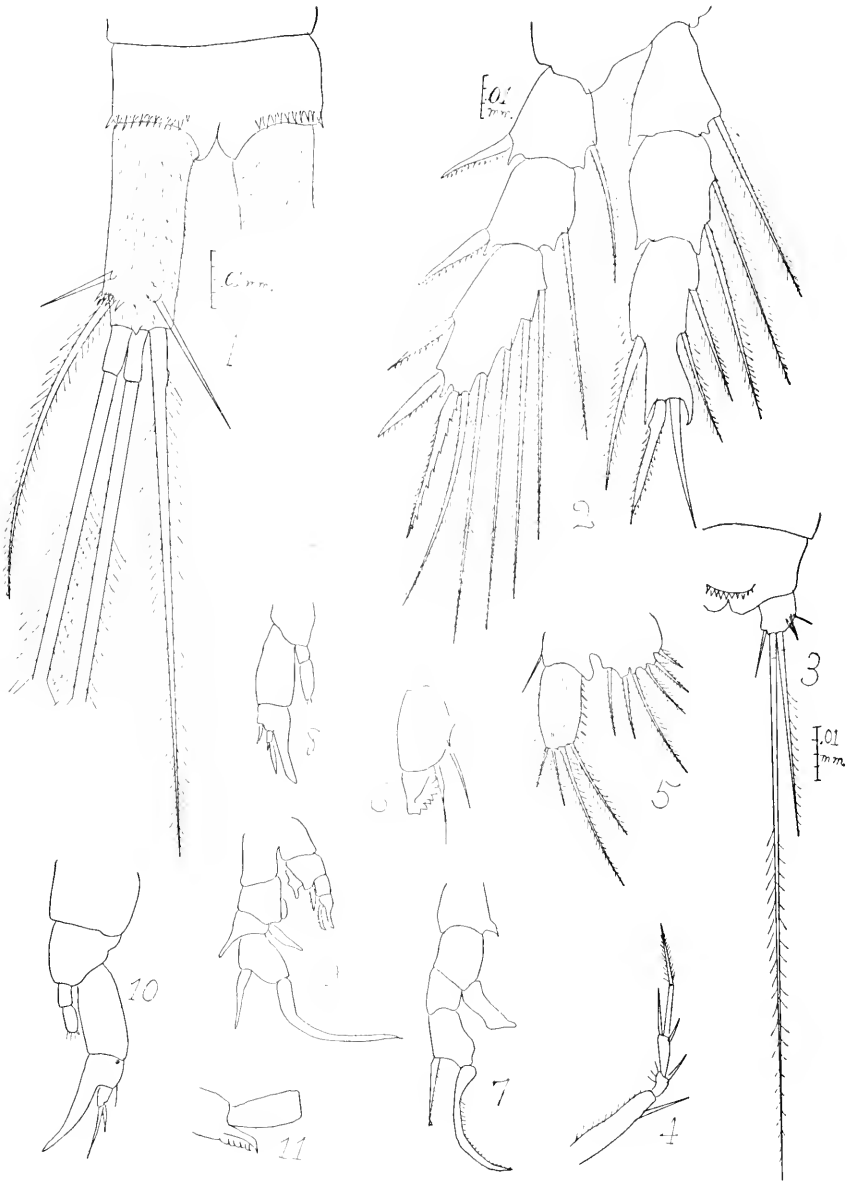
Diaptomus hirsus.

6. Left fifth foot of male.
7. Right fifth foot of male.
8. Fifth foot of female.

Diaptomus sancti-patricii.

9. Fifth foot of male.
10. Fifth foot of female.
11. Appendages of penultimate joint of right male antenna.

Figs. 6-11 are after Brady.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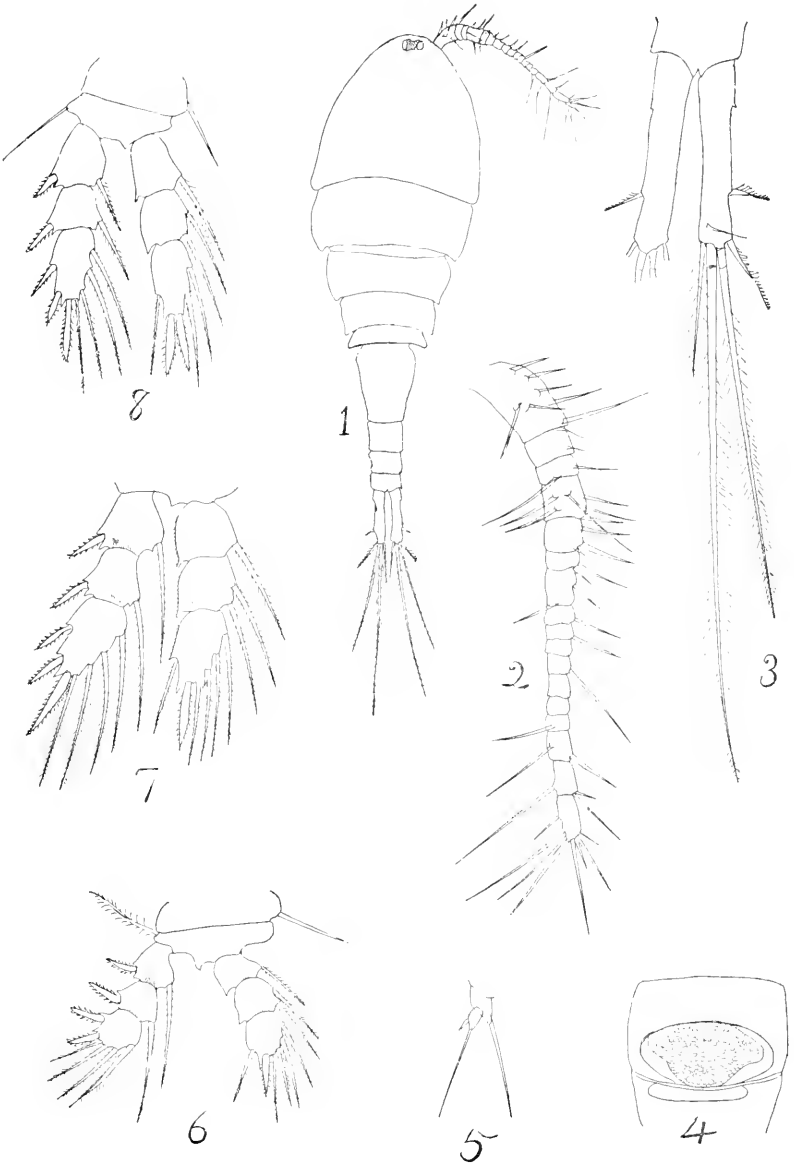
EXPLANATION OF PLATE XXXIV.

Cyclops parcus Herrick.

FIG.

1. Camera outline of female, elongate form.
2. Antenna of female. The relative length of the setæ of the apical joint is not quite accurately figured.
3. Caudal stylet of elongate form.
4. Receptaculum seminis.
5. Fifth foot.
6. Foot of first pair.
7. Foot of second pair.
8. Foot of fourth pair.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EXPLANATION OF PLATE XXXV.

Fig.

1-4. **Daphnia pulex** var. **nasutus.**

5. " **similis.** Outline of head and (a) beak.

6. **Leptodora hyalina.** Seen from above.

7. " **hyalina.** Larva.

8. **Latona setifera.** Female.

9. **Limnosida frontosa.** Female.

10. " **frontosa.** Antennule of male.

11. **Holopedium gibberum.** Female.

12. **Sida elongata.** Head outline.

13. " **crystallina.** Head outline of young female.

14. " **crystallina.** Antennule of male.

15. " **crystallina.** Antennule of female.

16. (**Daphnia hyalina**) "**D. galeata.**" Outline of head.

17. " " "**D. vitrea.**" Outline of head.

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EXPLANATION OF PLATE XXXVI.

FIG.

1. **Alona sp ?**

Pseudosida tridentata.

2. Female from above.
3. Antennule of female.
4. End of post-abdomen.
5. First foot.
6. Maxilla.

Moinadaphnia alabamensis.

7. Post-abdomen.
8. Antenna.
9. Female viewed from side.
10. Antennule.
11. One of the feet of *Pseudosida*.

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EXPLANATION OF PLATE XXXVII.

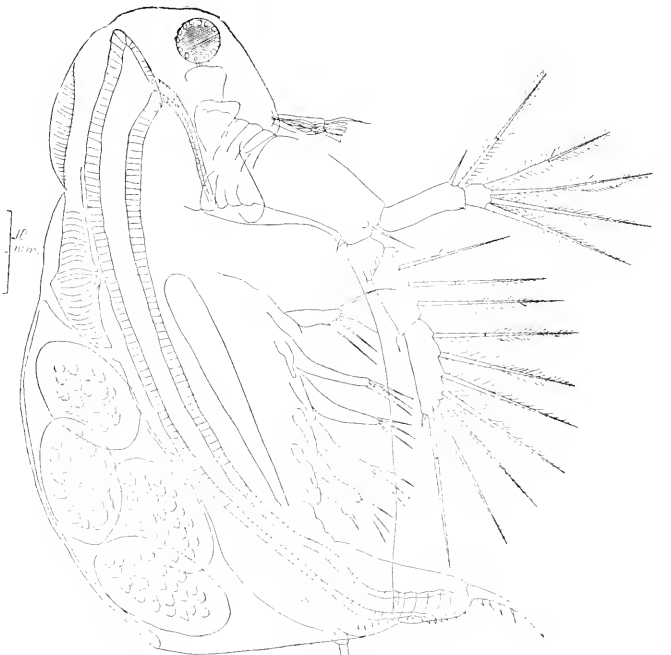
Sida crystallina.

FIG.

1. Female.
2. First foot.

Daphnella brandtiana.

3. Side view.
4. Antennule.
5. Inferior angle of shell.
6. Claw of post-abdomen.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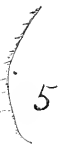
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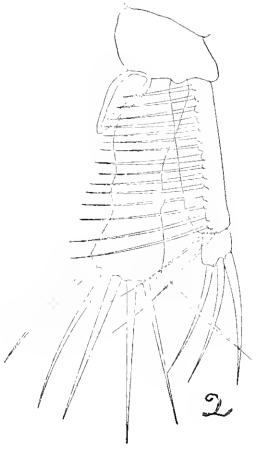
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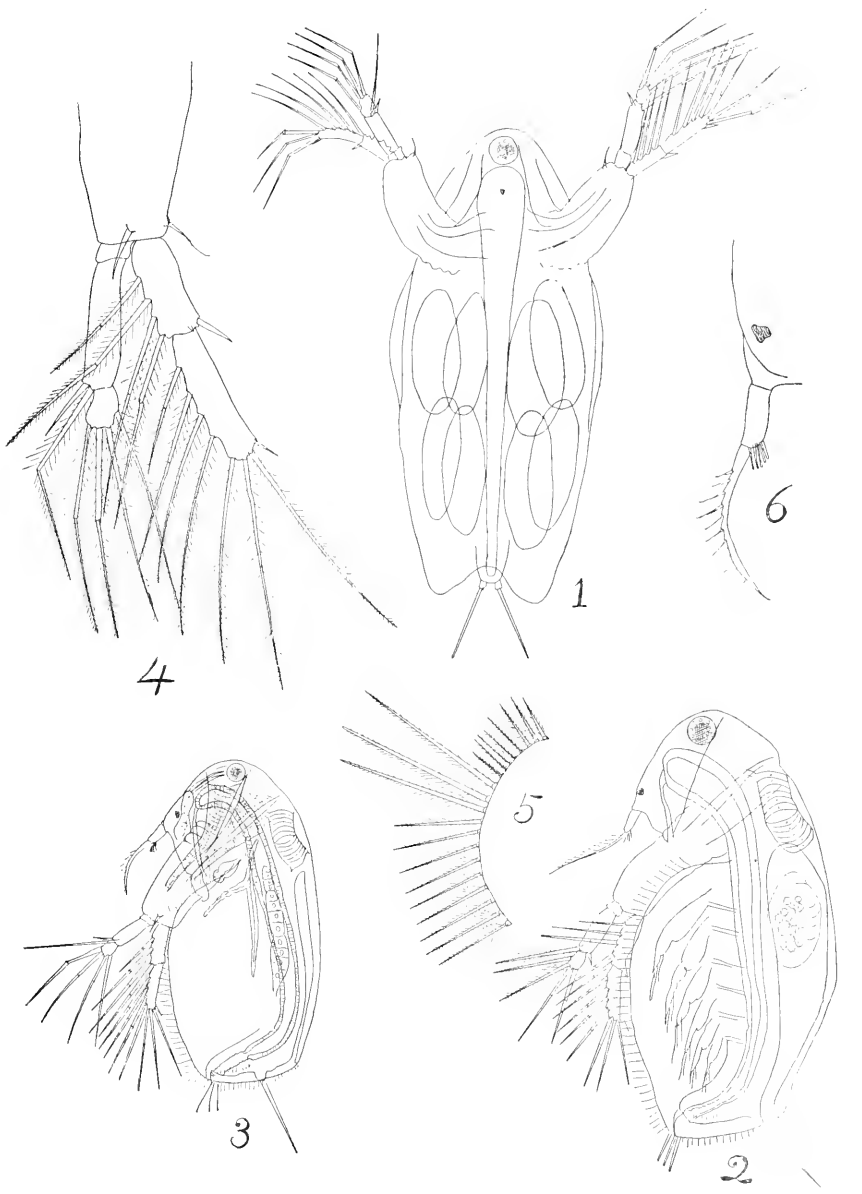
EXPLANATION OF PLATE XXXVIII.

Latonopsis occidentalis.

FIG.

1. Female from above.
2. Ephippial (?) female from the side.
3. Ordinary female from the side.
4. Antennæ with usual armature.
5. Inferior angle of shell.
6. Antennule.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EXPLANATION OF PLATE XXXIX

Moina rectirostris Mueller.

FIG.

1. Female with summer ova.
2. Portion of the shell near the postero-inferior angle.
3. Post-abdomen.
4. Antennule.

Moina brachiata Jurine.

5. Female with summer ova.
6. Antennule. The lateral flagellum is omitted.
7. Post-abdomen.
8. First foot of female.
9. **Moina paradoxa** Weismann. Ordinary form.

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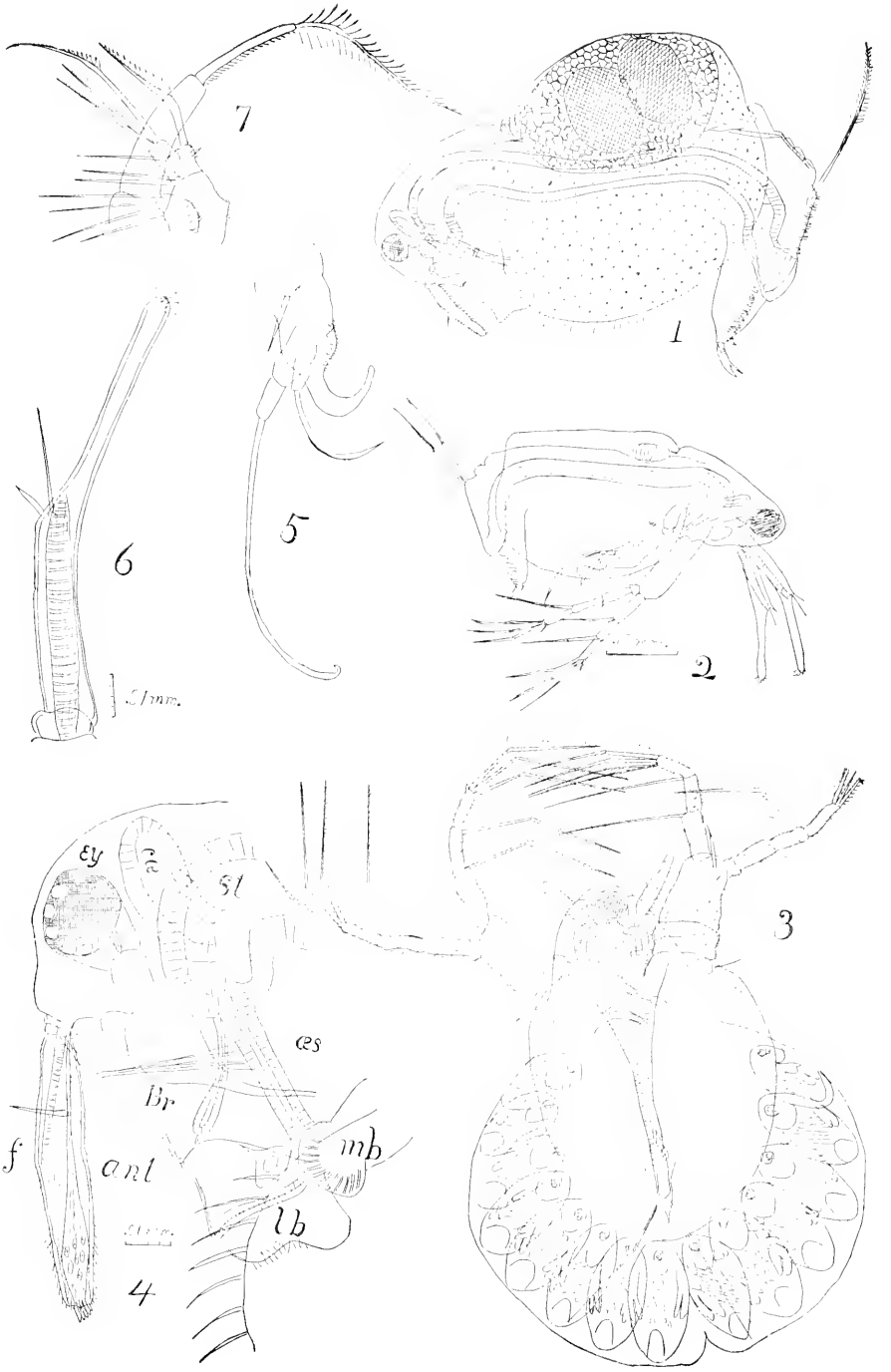
EXPLANATION OF PLATE XL.

Moina paradoxa Weismann.

FIG.

1. Adult female with ephippium. Antennæ omitted.
2. Male, from the side.
3. Adult female with summer eggs, seen from below.
4. View of the head, from the side. *St*, stomach; *ca*, cæcum of same; *Br*, brain; *ant*, antennule; *f*, flagellum of same; *lb*, labrum; *œs*, œsophagus; *ey*, eye; *mb*, mandible.
5. First foot of male.
6. Antennule of male.
7. First foot of female.

All the figures are camera drawings from New Mexican specimens.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EXPLANATION OF PLATE XLI.

FIG.

1. **Moina paradoxa.** Abdomen of female from Minnesota.
1a. " " Spine from post-abdomen.
2. " **rectirostris.** Post-abdomen.
3. " **paradoxa.** Head of female, showing: (*a*) eye with pigment and lenses, (*b*) supra-œsophageal ganglion, antennule with (*c*) its muscles, (*d*) its nerve, and (*e*) its terminal sensory filaments, (*f*) the cæcum of stomach, (*g*) optic ganglion, (*h*) stomach, (*i*) œsophagus, (*j*) the muscles which move the eye, also part of the labrum.
4. " **paradoxa.** Antennæ.
5. " **rectirostris.** Ephippium.
6. " **paradoxa.** Ephippium.
7. " " Seminal cell.
7a. " " A group of seminal cells less magnified.
8. " **rectirostris.** Seminal cells.
9. " **paradoxa.** First foot of male.
10 " **rectirostris.** First foot of male. (From Weismann).
11. " " Male. (From Weismann).
12. **Ceriodaphnia rotunda.** Head.
13. " **punctata.** "
14. " **pulchella.** "
15. " **reticulata.** "
16. " **quadrangula.** "
17. " " " (Variety.)
18. " " Post-abdomen.
19. " **pulchella.** "
20. " **megops.** "
21. " **reticulata.** "
22. " **laticaudata.** "
23. " **rotunda.** "

Figures 12-23 are after P. E. Mueller.)

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EXPLANATION OF PLATE XLII.

FIG.

1. **Ceriodaphnia rotunda.** Male (after Kurz).
2. " **alabamensis.** Female.
3. " **reticulata.** Post-abdomen of male with opening of vas deferens (after Weismann).
4. " **consors?**

Ceriodaphnia scitula.

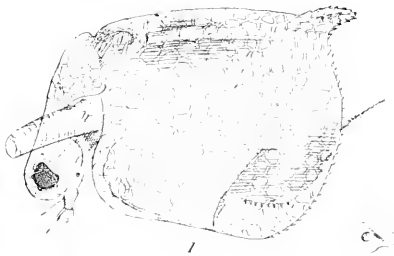
5. Head of female.
6. Post-abdomen.
7. Antennule of male.
8. Semen cells of male.
9. **Scapholeberis angulata.** Adult female.

9a. " **angulata.** First foot.

10. " **armata.** Adult female.
11. " **armata.** From below.

Ofryoxus gracilis.

12. Young.
13. Labrum.
14. Antennule.
15. Last foot. Purple pigment in lower part.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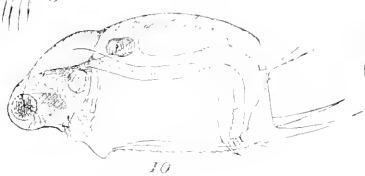
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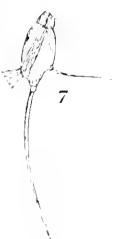
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EXPLANATION OF PLATE XLIII.

Moina brachiata

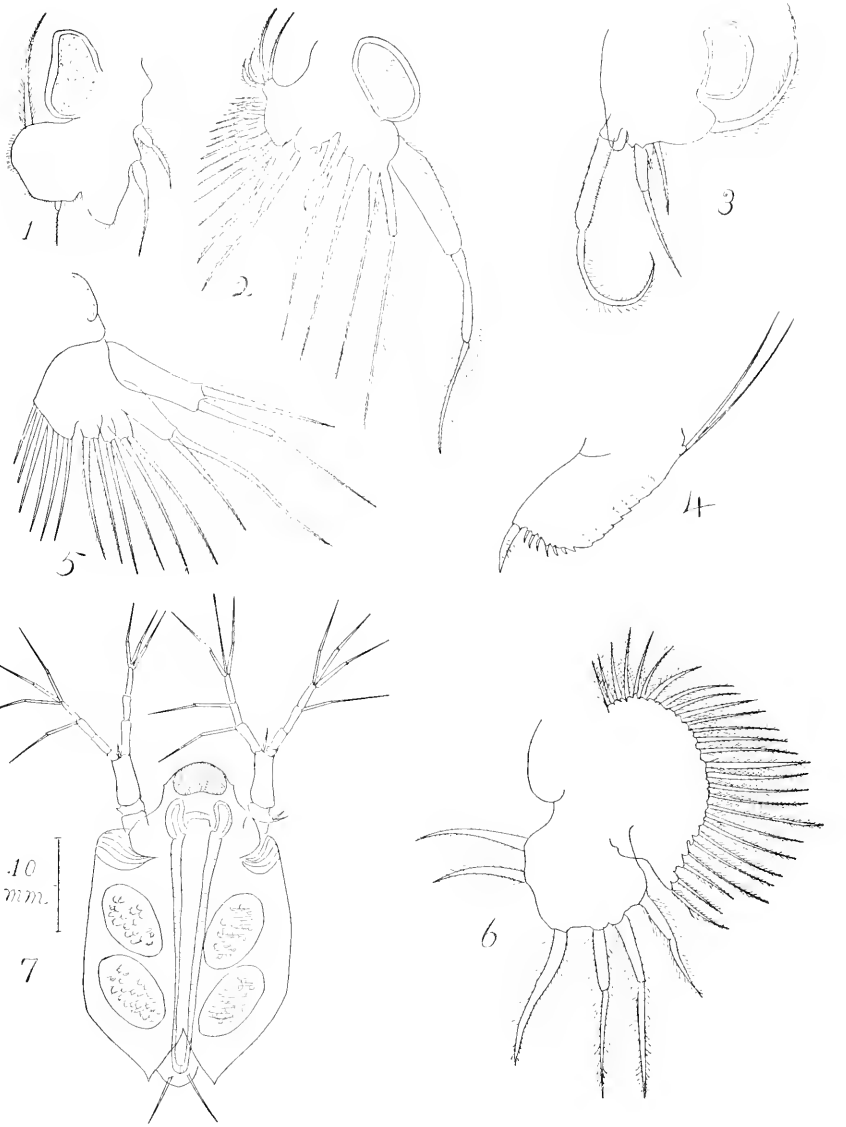
FIG.

1. Leg of fifth pair, after Lund.
2. Leg of third pair.

3. **Ceriodaphnia reticulata.** Leg of fifth pair.

Scapholeberis mucronata.

4. Post-abdomen.
5. Foot of second pair.
6. Foot of fourth pair.
7. Female, seen from above.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EXPLANATION OF PLATE XLIV.

Ceriodaphnia scitula.

FIG.

1. Head.
2. Post-abdomen.

Ceriodaphnia reticulata.

3. Post-abdomen.
4. Head.

Ceriodaphnia consors.

5. Post-abdomen.
6. Head.

7. **Simocephalus vetulus.** Foot of second pair.

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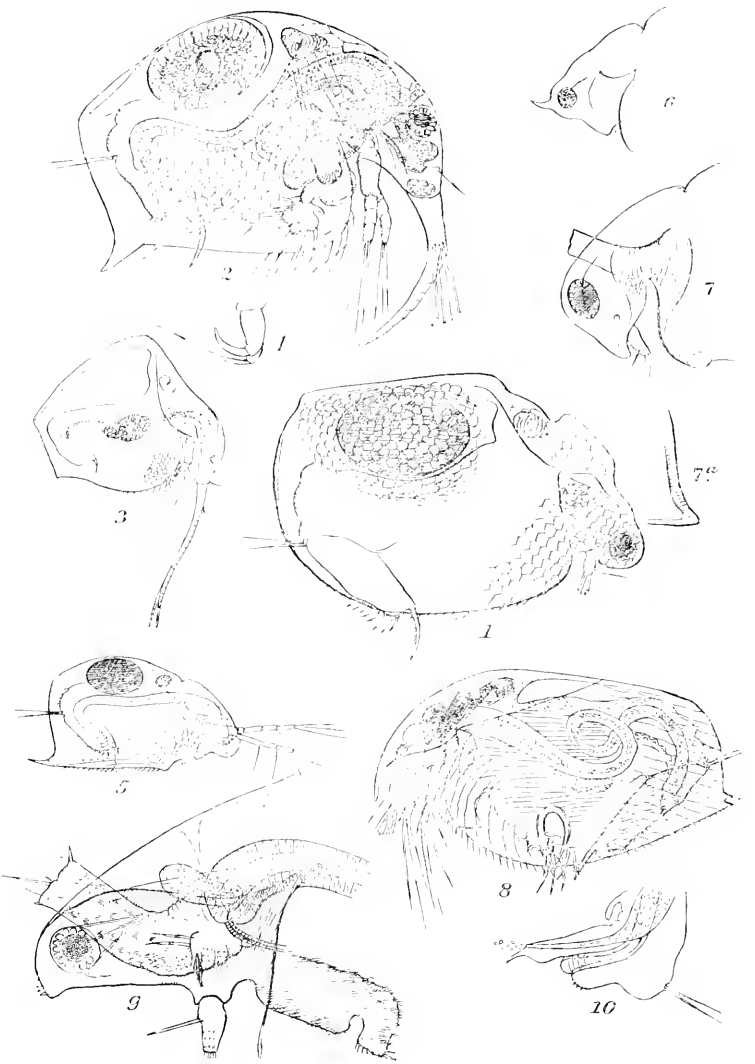
EXPLANATION OF PLATE XLV.

FIG.

1. **Ceriodaphnia scitula** (small variety). Ephippial female.
2. **Bosmina longirostris.**
3. " **lilljeborgii.** After P. E. Mueller.
4. " Hook on the first foot of male.
5. **Scapoleberis mucronata.**
6. " **cornuta.** Head.
7. " **angulata.** Head.

7a. " **angulata.** Angle of shell.

8. **Pleuroxus denticulatus.** Male.
9. **Simocephalus americanus.** Head of female.
10. **Bosmina.** Post-abdomen of male (after Weismann).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EXPLANATION OF PLATE XLVI.

Acantholeberis curvirostris.

FIG
1. First foot.
2. Fourth foot.
3. Fifth foot.
4. Lateral view of female.

Simocephalus daphnoides.

5. Lateral view.
6. Lower posterior angle of shell.

Eurycercus lamellatus.

7. First foot.
8. Caudal claws.
9. **Drepanothrix dentata.** Post-abdomen of male. After Birge.

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EXPLANATION OF PLATE XLVII.

Diaptomus mississippiensis Marsh.

FIG.

1. Fifth foot of male.
2. Abdomen of female.
3. Fifth foot of female.

Diaptomus birgei Marsh.

4. Fifth foot of male.
5. Fifth foot of female.
6. Terminal joints of male antenna.

Canthocamptus minutus.

7. Lateral view of male. ["*a*, testis; *b*, cephalic ganglion; *c*, blood sinus or dorsal vessel surrounding the intestine; *d*, anus; *e*, œsophagus; *f*, frontal sensory plate."]
8. Caudal stylet.
9. Antenna of male.
10. Antennule.
11. Foot of first pair.
12. Foot of second pair.
13. Foot of third pair.
14. Foot of fourth pair.
15. First maxilliped.
16. Mandible.
17. Spermatophore.
18. Foot of third pair of male.
19. Foot of fifth pair of male.
20. Foot of fifth pair of female.
21. Maxilla.

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EXPLANATION OF PLATE XLVIII.

Phyllopod Larvæ.

FIG.

1. Larva of *Limnetes* 0.33 mm. long. A^1, first antenna; A^2, swimming antenna; *Md*, mandibular palp; *e*, eye; *l*, lens; *L*, liver budding from anterior part of stomach; *s*, sensory filament; *m*, muscles of rectum.

Larva of Chirocephalus.

2. View from below.
3. Caudal stylet.
4. Head, showing organs of one side. *L*, liver.
5. Muscles of swimming antennæ.
6. Maxilla.
7. End of abdomen of an older individual.
8. Mandible and palpus (*p*) in this stage.
9. Antenna of female.
10. Antenna of male. *p*, inner ramus; *g*, frontal organ.
11. Part of *Limnetes* older than Fig. 1.
12. First abdominal segment of female seen from below. This plate illustrates the relation between the *Phyllopoda* and the *Cladocera* on one hand (*Limnetes*) and the *Copepoda* on the other (*Chirocephalus*).

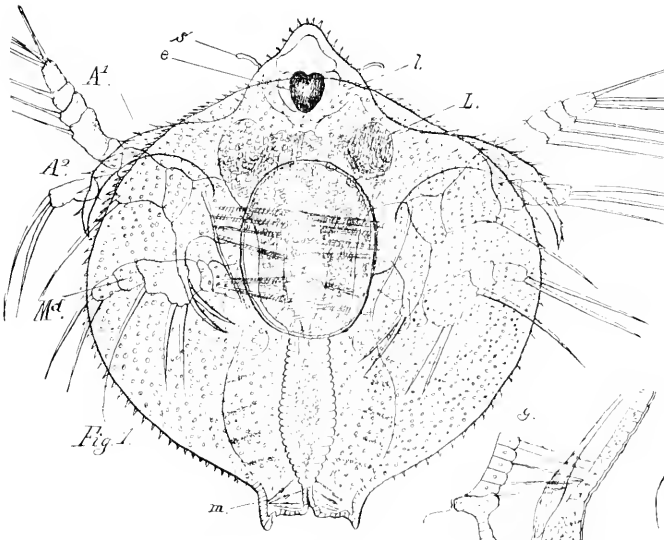


Fig. 1.

Fig. 5.

Fig. 3.

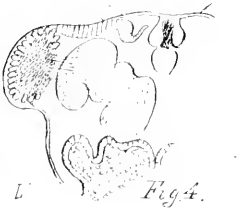


Fig. 4.

Fig. 8.

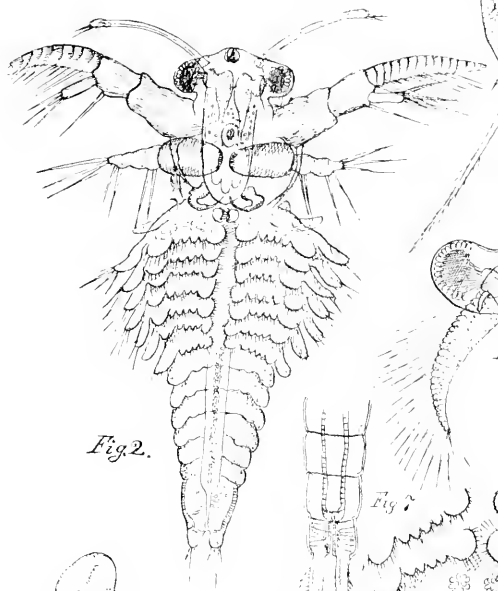


Fig. 2.

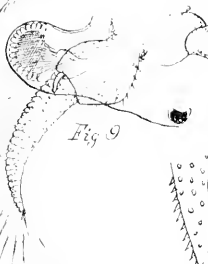


Fig. 9.

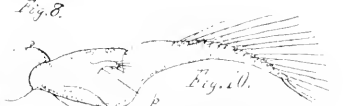


Fig. 10.

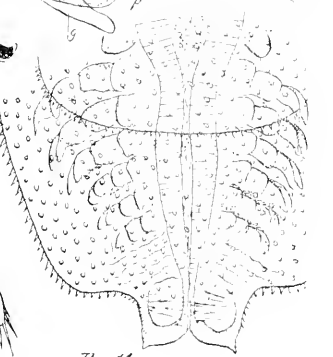


Fig. 11.

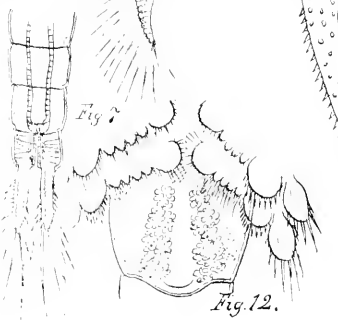


Fig. 12.

Fig. 6.

Fig. 7.

EXPLANATION OF PLATE XLIX.

Daphnia minnehaha.

FIG.

1. Young female.
2. Head of female.

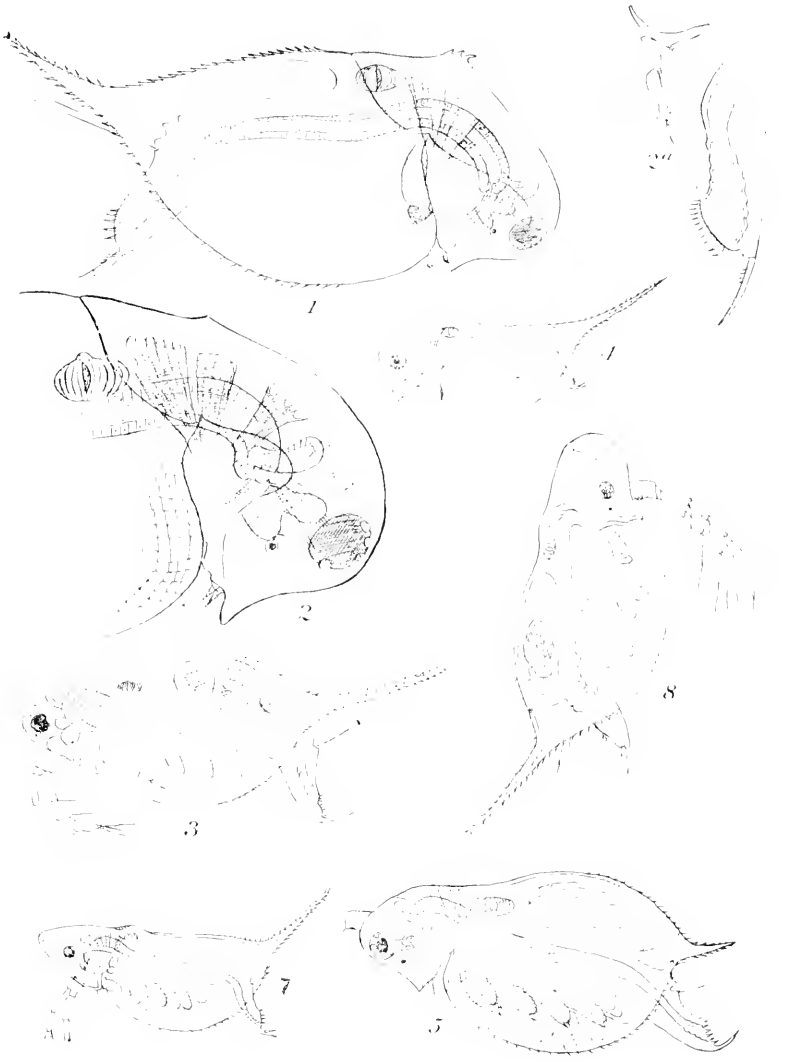
2a. Post-abdomen.

Daphnia hyalina.

3. Young female.
4. Young.
5. Post-imago.

Daphnia dubia.

7. Young.
8. Older female.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EXPLANATION OF PLATE L.

FIG.

1. **Daphnia minnehaha.** Male.
2. " **minnehaha.** Part of feet of first and second pair.
3. **Canthocamptus hibernicus.** Antenna of female.
4. " **hibernicus.** Fifth foot of female.
5. " **palustris.** Antenna of male.
6. " **trispinosus.** Fifth foot of female.
7. " **minutus.** Young.
8. " **minutus.** Nauplius form.
9. **Pseudo-sida tridentata.** Adult female, antennule, labrum, angle of shell, and post-abdomen.
10. **Daphnia minnesotensis.** Young female.
11. " **minnesotensis.** Post-imago.
12. " **minnesotensis.** Beak.

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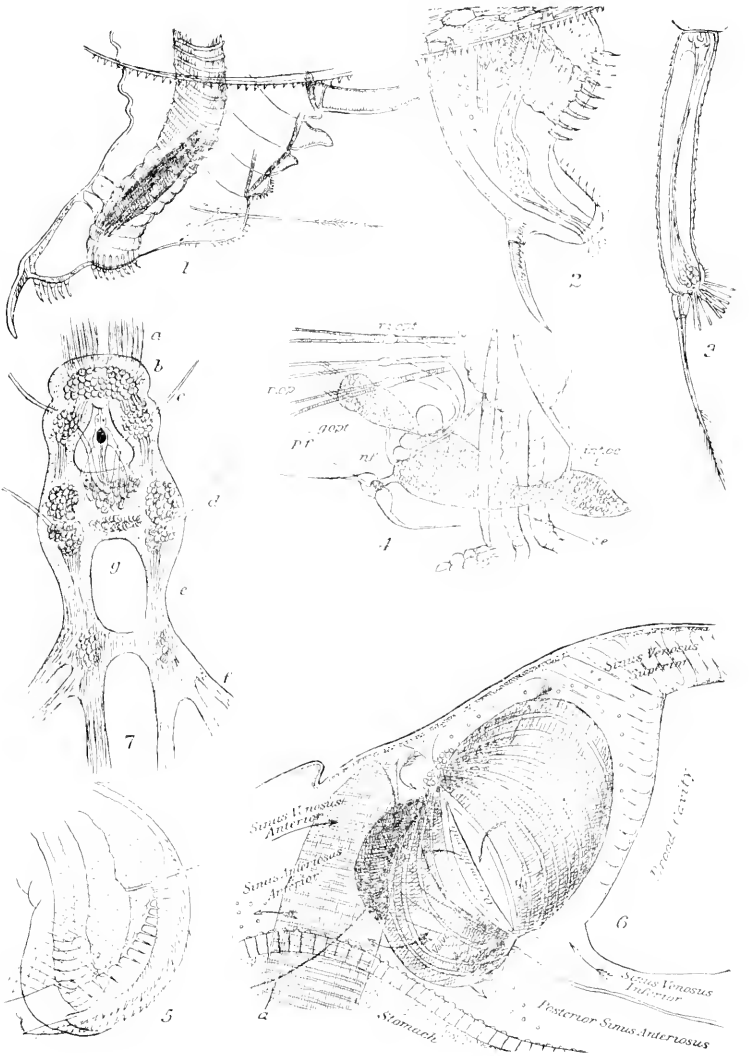
EXPLANATION OF PLATE LI.

Daphnia schæfferi.

FIG.

1. Post-abdomen of female.
2. Post-abdomen of male.
3. Male antennule.
4. Brain and nerves. Inf. œ. g., infra-œsophageal ganglion with nerves to antennæ; œ., œsophagus; n. f., frontal nerve; g. opt., optic ganglion; m. opt., muscles which move the eye; p. f., pigment fleck; n. opt., optic nerve.
5. Posterior part of embryo.
6. **Eurycercus lamellatus.** Heart, showing the anterior bifid portion between the lobes of which is the arterial opening and valve. The vaned arrows represent deeper currents while the unvaned indicate superficial ones. The dotted line represents the position of the pulsating membrane separating the venous from the arterial currents and seen in section at (a).
7. **Daphnia similis.** Anterior part of the nervous system seen from below. a, optic nerve; b, optic ganglion; c, frontal nerve; d, nerve to antennules; e, commissure connecting upper and lower œsophageal ganglion; f, nerves to antennæ and mandibles. [After Claus.]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Sinus Venosus Anterior
Sinus Arteriosus Anterior
Sinus Venosus Posterior
Sinus Venosus Inferior
Posterior Sinus Arteriosus
Stomach

EXPLANATION OF PLATE LII.

Daphnia minnehaha.

Fig.

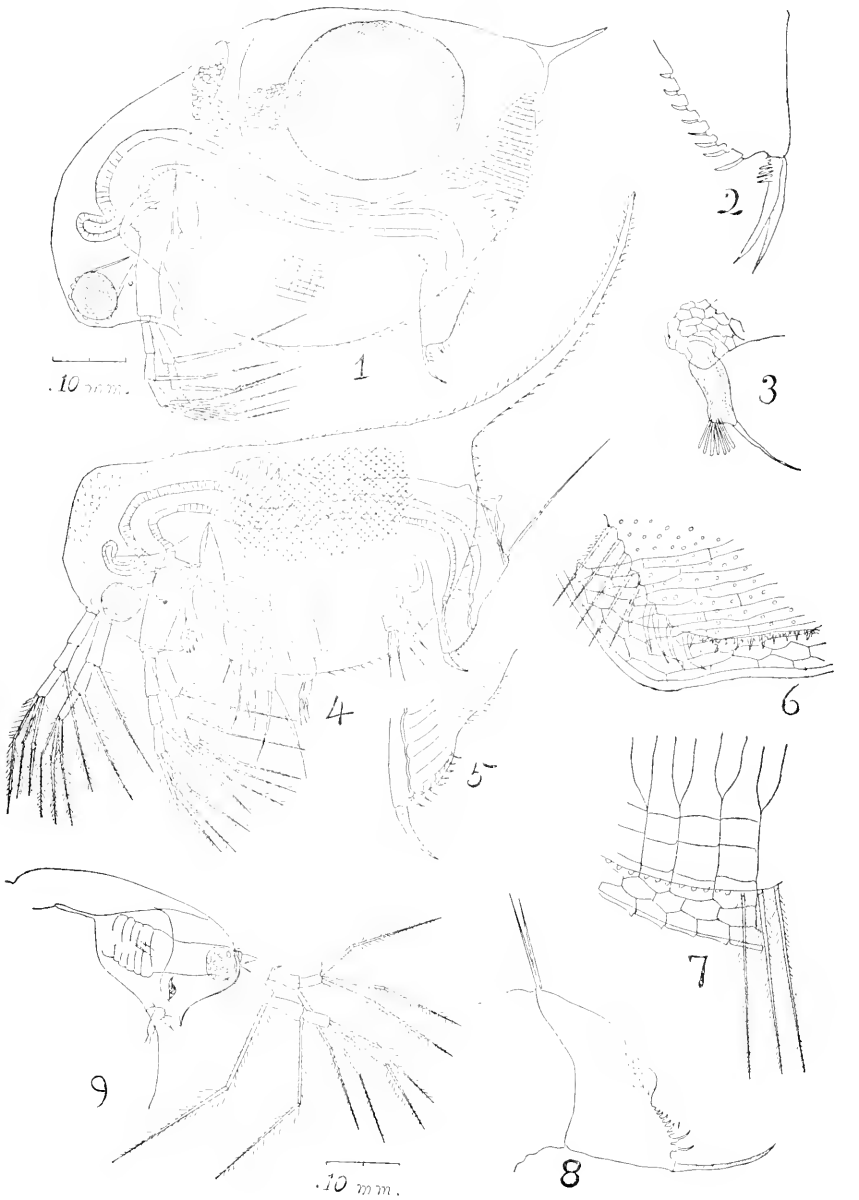
1. Ephippial female.
2. Post-abdomen.
3. Antennule of male.

Daphnia exilis.

4. Female.
5. Post-abdomen.

Simocephalus vetulus.

6. Caudo-ventral angle of shell. The markings are on the outer lamina.
7. Margin of shell cephalad.
8. Post-abdomen.
9. Head.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EXPLANATION OF PLATE LIII.

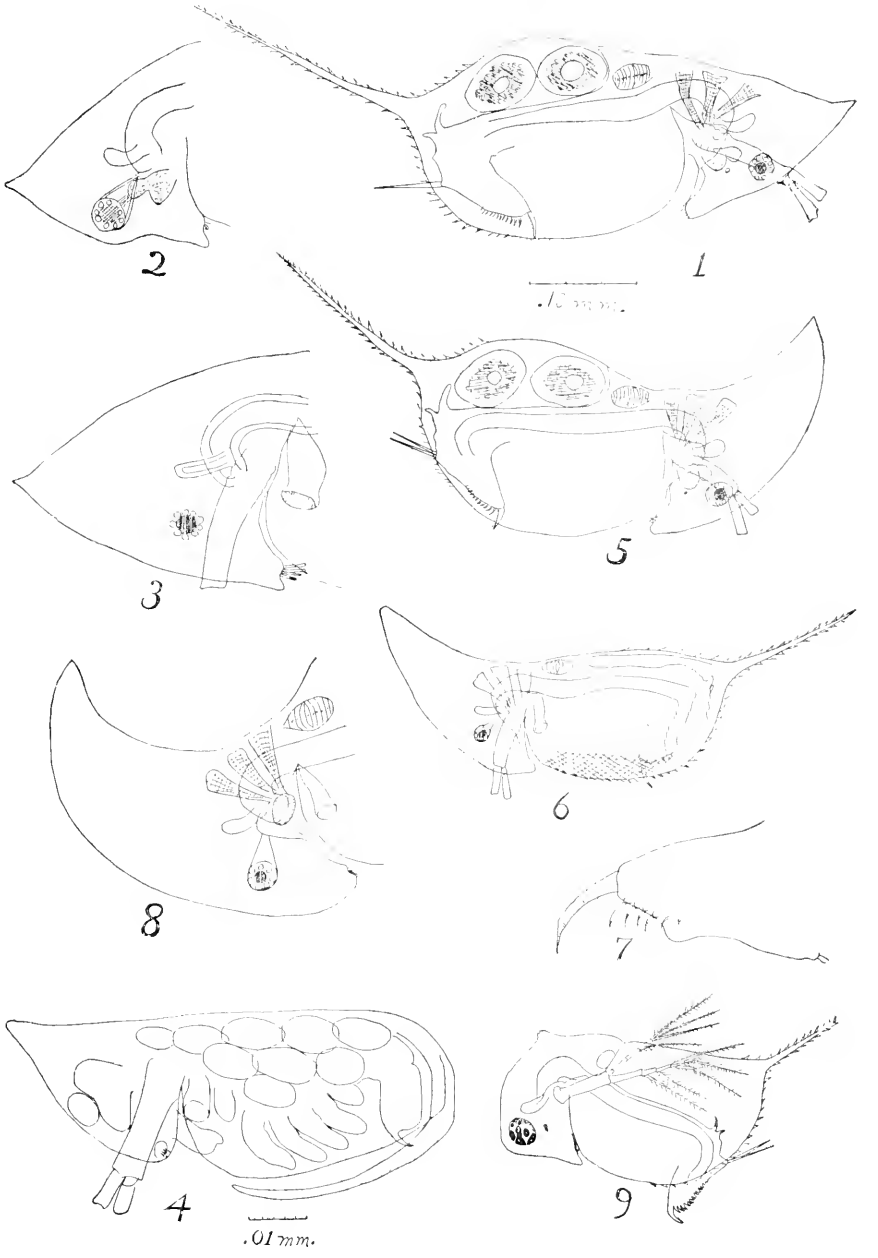
Daphnia hyalina Leydig.

FIG.

1. Outline of female from Lake Minnetonka drawn to the same scale as figure 5.
2. Head of a common form of the above species.
3. Extreme development of the crest.
4. Embryo illustrating the early development of the helmet.

Daphnia kalbergensis Schoedler.

5. Typical form, from Lake Minnetonka.
6. A form of the above taken from the same gathering.
7. Post-abdomen of the above.
8. Extreme development of head resembling *D. retrocurva* Forbes, from same gathering as the above.
9. **Daphnia dentifera** Forbes. Copy from "Aquat. Invert. Wyoming."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EXPLANATION OF PLATE LIV.

Macrothrix rosea.

Fig.

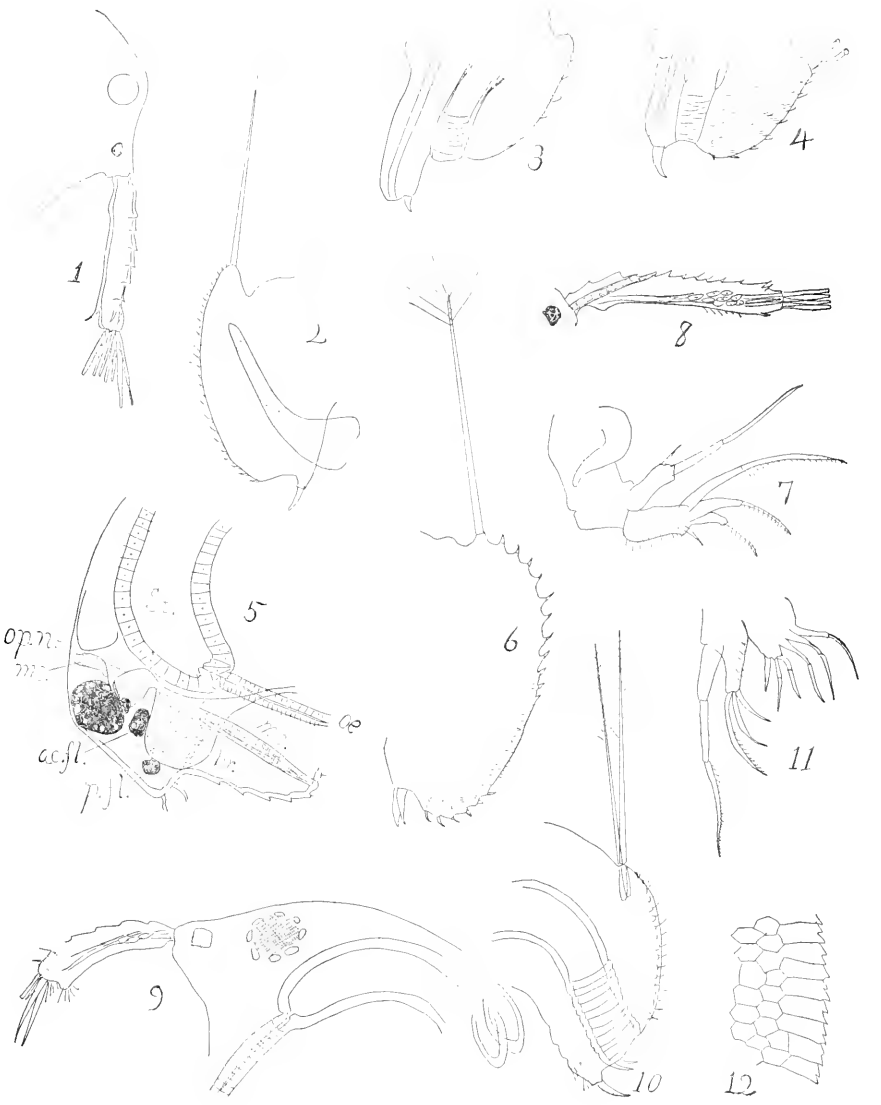
1. Antennule.
2. Post-abdomen of female.
3. Post-abdomen of male.
4. **Drepanothrix dentata.** Post-abdomen of male.

Macrothrix tenuicornis.

5. Head.
6. Post-abdomen.
7. First foot.
8. Antennule of female.

Macrothrix laticornis.

9. Head.
10. Post-abdomen.
11. First foot.
12. Portion of dorsal ridge of shell.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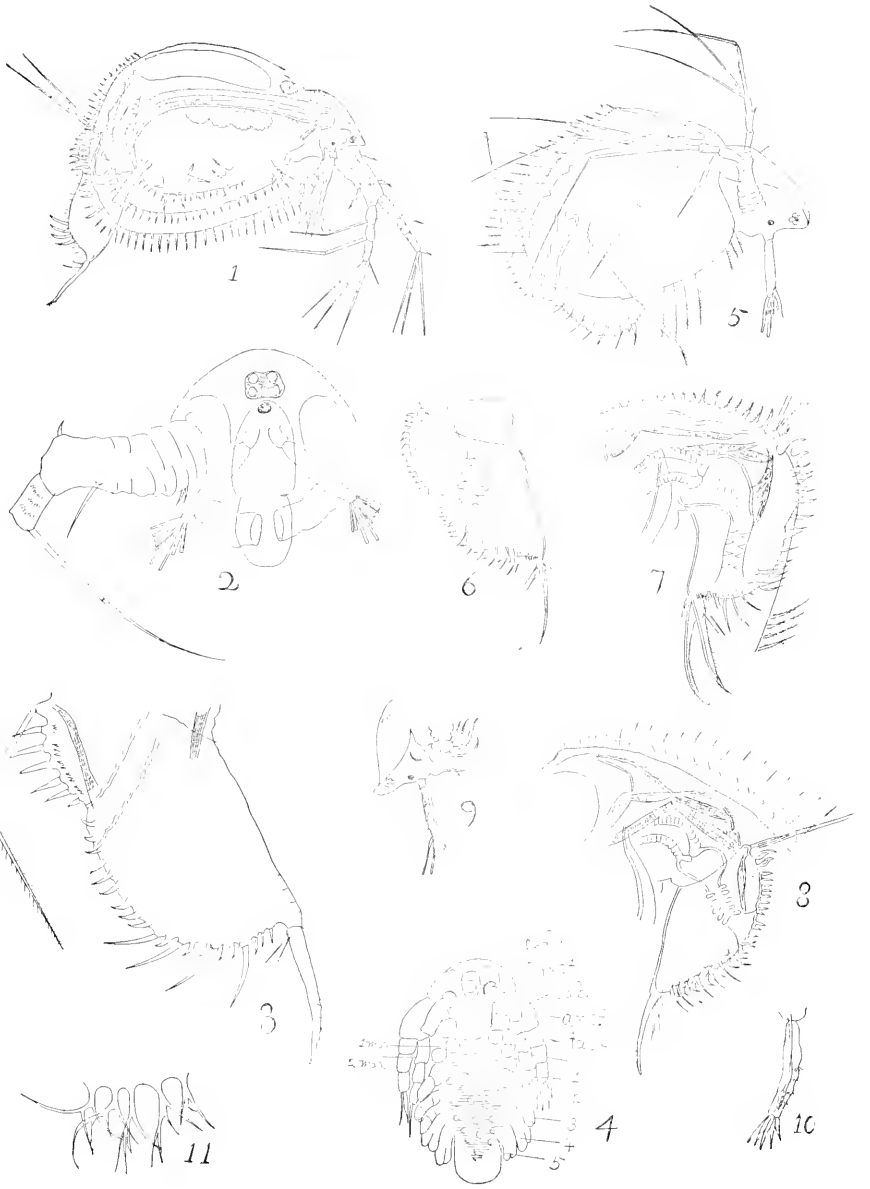
EXPLANATION OF PLATE LV.

Ilyocryptus spinifer.

FIG.

1. Lateral view.
2. Head, from below.
3. Post-abdomen.
4. Embryo.
5. **Ilyocryptus longiremis.**
6. " **sordidus.** Post-abdomen.
7. " **acutifrons.** Post-abdomen.
8. " **agilis.** Post-abdomen.
9. " **agilis.** Head.
10. " **sordidus.** Antennule.
11. " **sordidus.** Spines on free margin of shell.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EXPLANATION OF PLATE LVI.

Macrothrix tenuicornis.

FIG.

1. Lateral view.
1a. Labrum.
2. First foot.
3. Antennæ of young.
4. **Macrothrix pauper.**

Macrothrix rosea.

5. Antenna of male.
6. Spines of shell margins.
7. Post-abdomen.

Macrothrix laticornis.

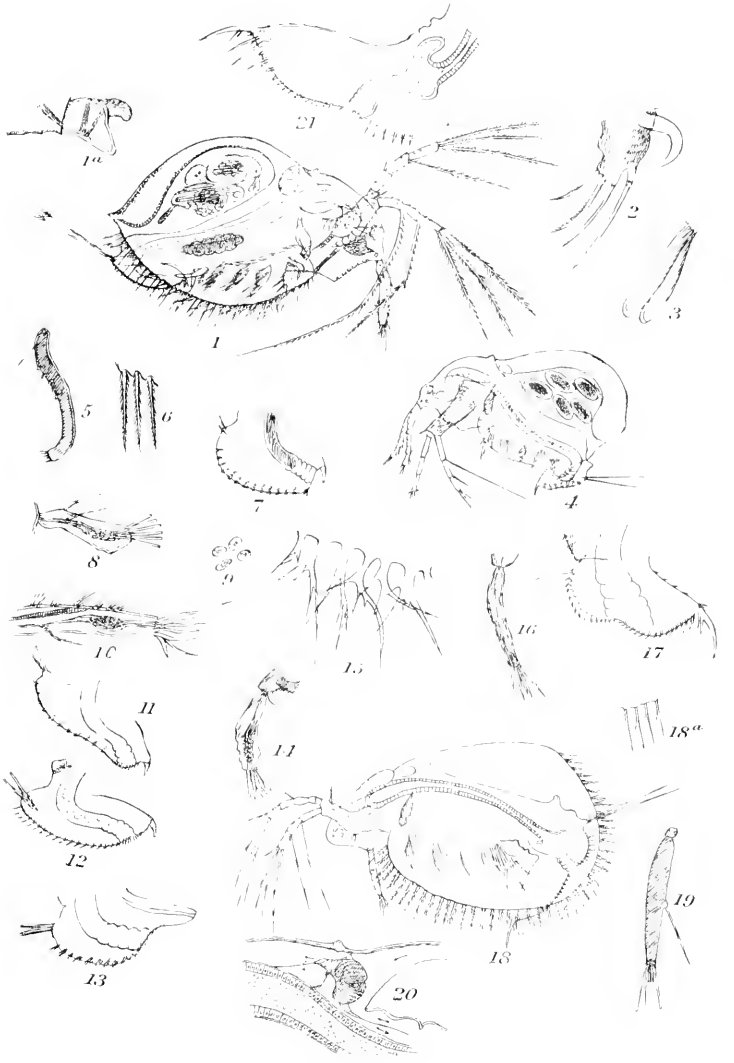
8. Male.
9. Semen cells.
10. **Pasithea rectirostris.** Male antenna.
11. **Macrothrix rosea.** Post-abdomen.
12. " **tenuicornis.** Post-abdomen.
13. " **rosea.** Post-abdomen of male.
14. **Drepanothrix dentata.** Antenna.

Ilyocryptus sordidus.

15. Marginal spines.
16. Antenna.
17. Post-abdomen.

Ilyocryptus spinifer.

18. Lateral view.
18a. Marginal spines.
19. Antenna.
20. **Macrothrix tenuicornis.** Heart and accompanying vessels.
21. **Ilyocryptus spinifer.** Post-abdomen.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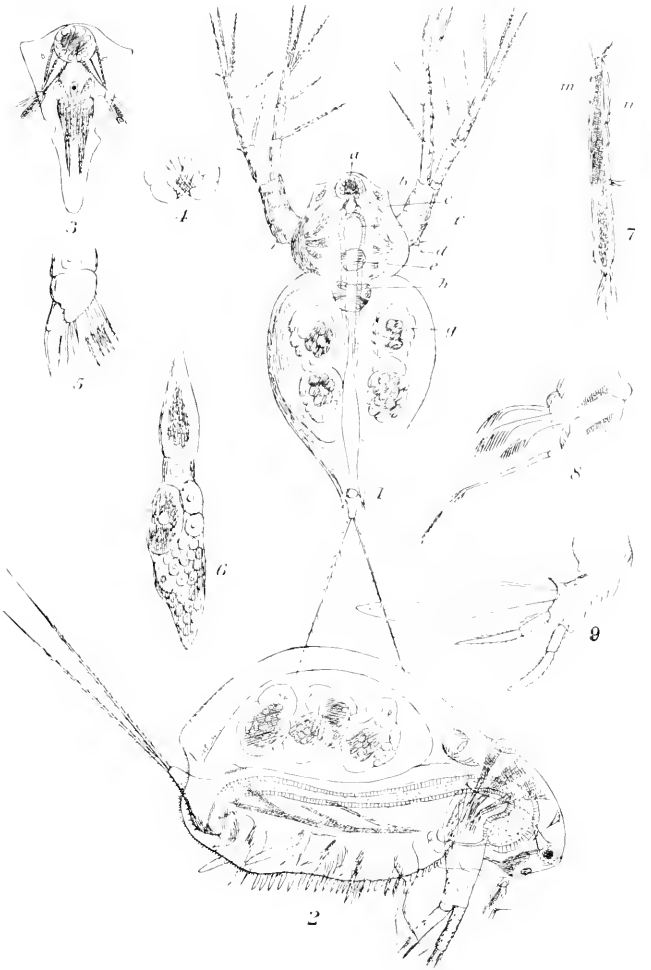
EXPLANATION OF PLATE LVII.

Lathonura rectirostris.

FIG.

1. Female, from above. a, eye; b, optic ganglion; c, muscles of eye; d, muscles of antenna; e, dorsal sucking disc; f, stomach; g, young in brood cavity; h, heart.
2. Female, from side.
3. Head seen from below.
4. Maxillæ.
5. First foot.
6. Ovary.
7. Antennule
8. Last foot.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EXPLANATION OF PLATE LVIII.

Ofryoxus gracilis.

FIG.

1. Adult female, showing coiled intestine, elevated anus, long antennule, elongated seta of second antenna, anterior cæca, etc.
2. Post-abdomen.
3. Antennule.

4-6. **Polyphemus pediculus.** Young and adult females.

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EXPLANATION OF PLATE LIX.

FIG.

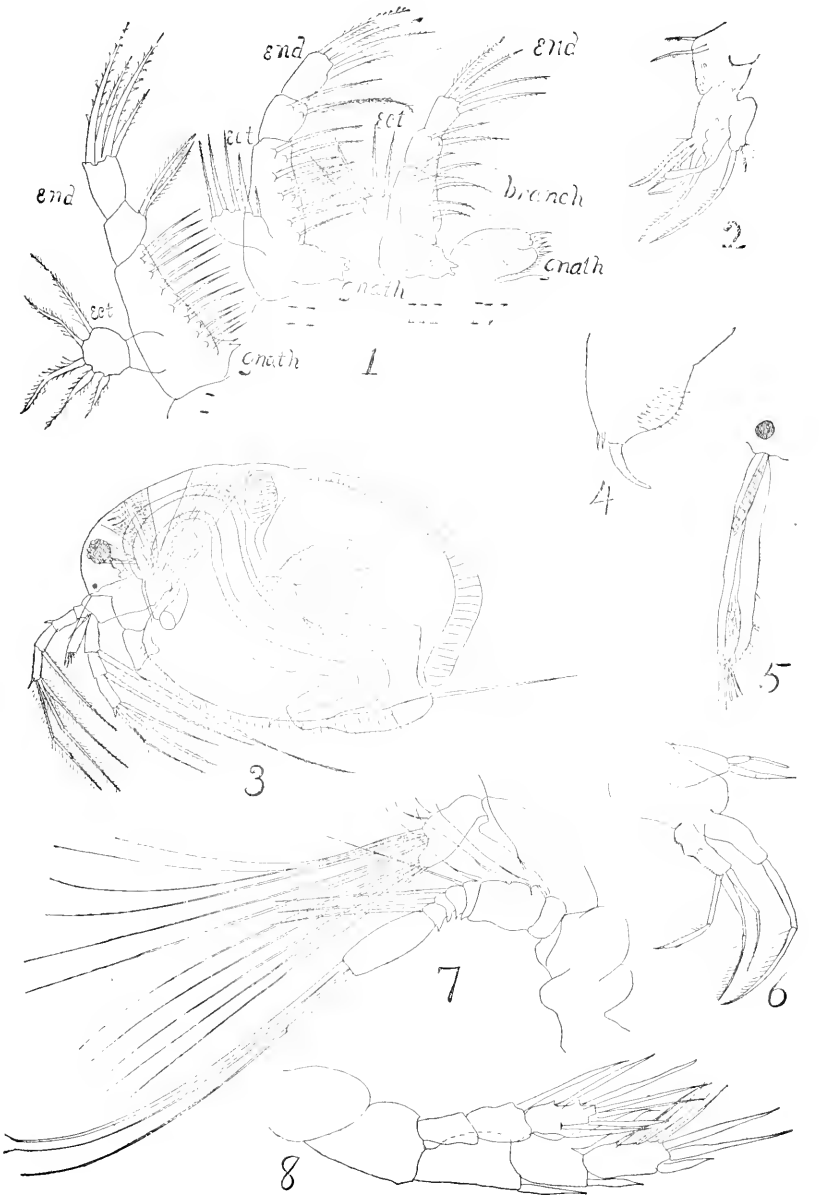
1. **Polyphemus pediculus.** Swimming feet.
2. **Ofryoxus gracilis.** First foot.

Macrothrix nova-mexicana.

3. Female.
4. End of post-abdomen.
5. Antennule.
6. **Leydigia quadrangularis.** First foot.

Osphranticum labronectum.

7. Antennule.
8. Fifth foot of female.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EXPLANATION OF PLATE LX.

FIG.

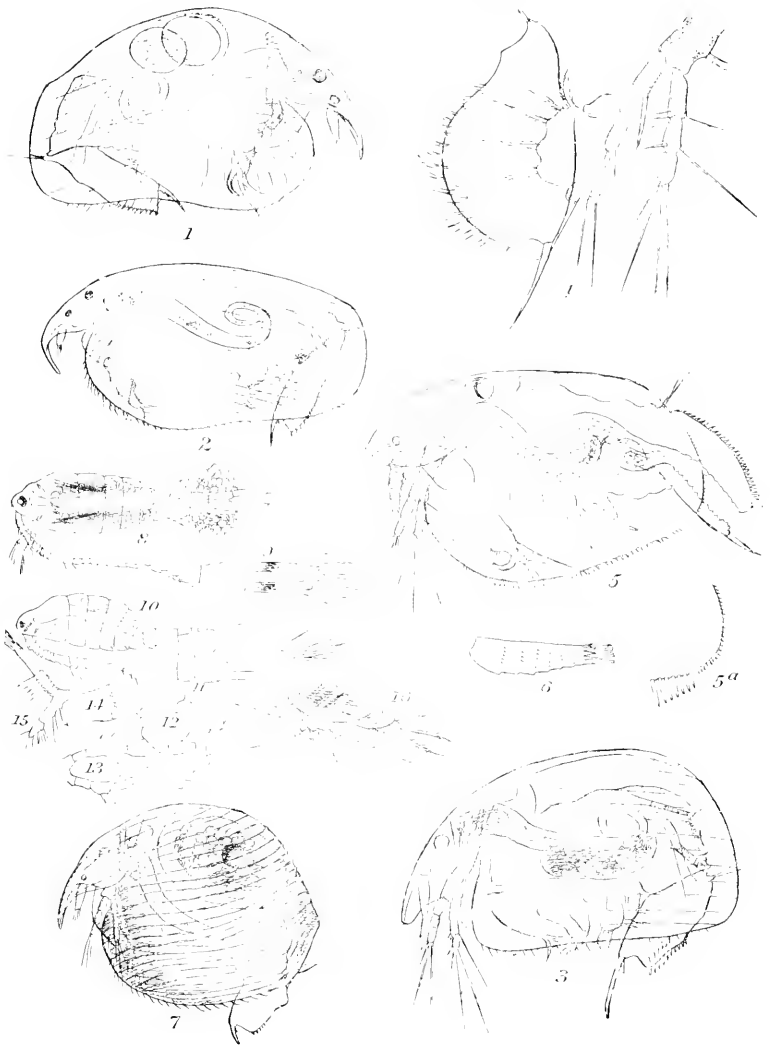
1. **Pleuroxus hamatus.** Post-abdomen and antenna.
2. " **affinis.**
3. **Alona costata.**
4. **Leydigia quadrangularis.**

Eurycercus lamellatus.

5. Male.
5a. Posterior margin.
6. Antenna of female.
7. Alonella pygmæa.

Eurytemora affinis Poppe.

8. Female.
9. Female abdomen.
10. Male.
11. Male abdomen.
12. Fifth feet of male.
13. Fifth feet of female.
14. Jaw.
15. Antennule.
16. Nauplius larva of this or a related species.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EXPLANATION OF PLATE LXI.

Alona quadrangularis.

FIG.

1. Female. A^1., antennule; Lb., labrum; Md., mandible; P-a., post abdomen; An.,anus; F. c., musculus flexor caudalis; E. c., musculus extensor caudalis; A. g., anal gland; n. gl., nutritive globule in embryo; t., tail of embryo; I, II, III, IV, V, five pairs of feet of embryo; mx., maxilla of embryo; at^2., antennæ of embryo; at^1., antennules of embryo; H., heart; sh. g., shell gland; ov., ovary; Md. m., muscle of mandible; At^2. m., muscle of antenna; E., eye; Sœ. g., supra-œsophageal ganglion; P. f., pigment fleck.
2. Brain, eye and pigment fleck of same.

Pleuroxus procurvus.

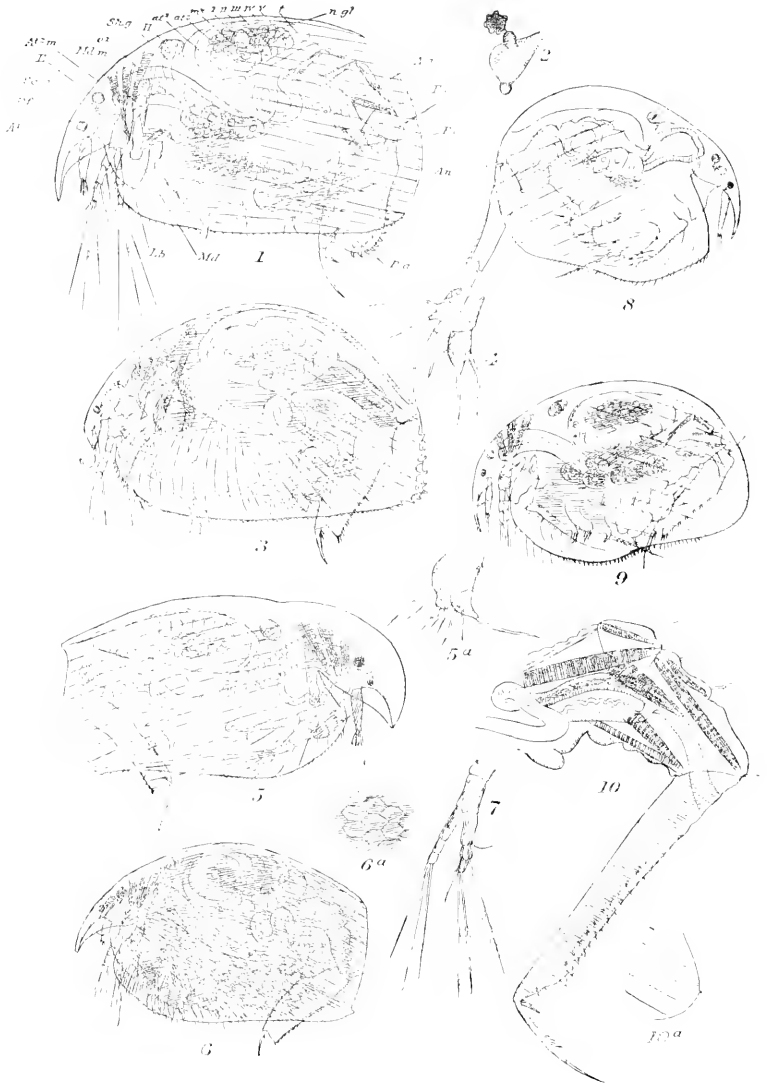
3. Female.
4. Foot of same.
5. **Acroperus leucocephalus.**

Alonella excisa.

6. Female.
6a. Shell of same.
7. Antenna of same.
8. **Alonopsis latissima.** Female.
9. " **latissima** var. **media.** Female.

Camptocercus macrurus.

10. Post-abdomen.
10a. Lower angle of shell of same.



EXPLANATION OF PLATE LXII.

Camptocercus rectirostris.

FIG.

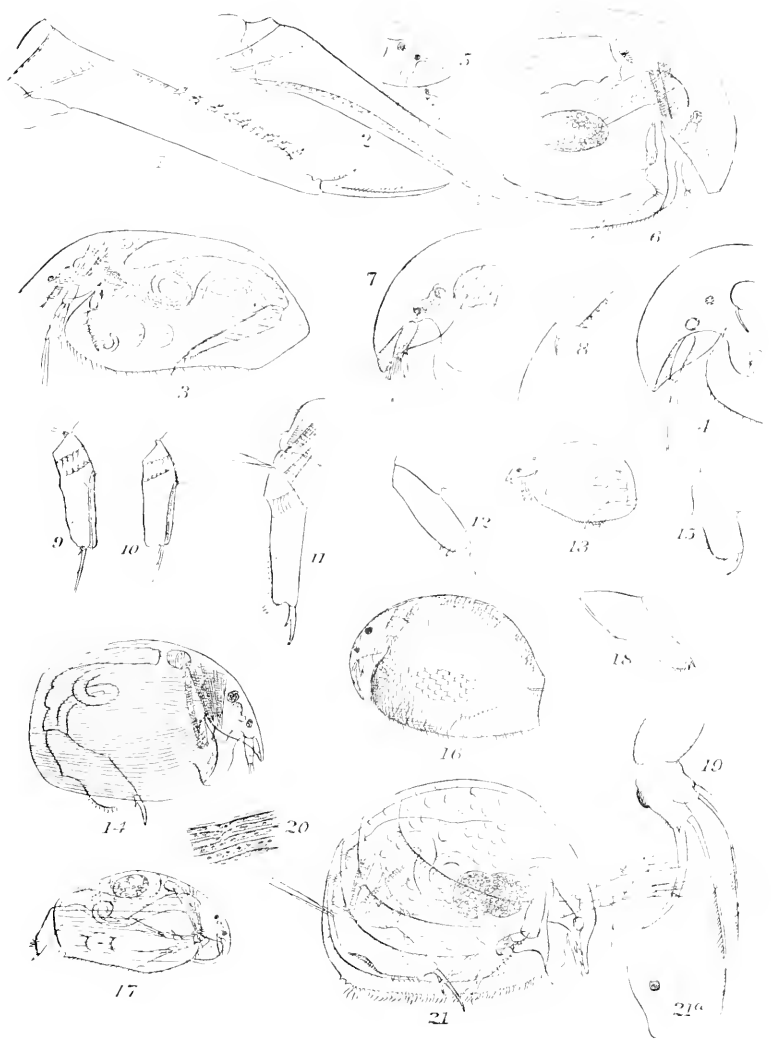
1. Post-abdomen of female.
2. Post-abdomen of male.
3. Male.

4. **Camptocercus biserratus.** Head.
5. " **latirostris.** Head of male.
6. " **latirostris.** Head of female.
7. " **lilljeborgii.** Head.
8. " **lilljeborgii.** Post-abdomen of female.
9. **Acroperus leucocephalus.** Post-abdomen of male.
10. " **angustatus.** Post-abdomen of male.
11. **Alona tenuicaudis.** Post-abdomen.
12. " **dentata.** Post-abdomen.
13. " **dentata.** Female.
14. " **elegans.**
15. " **intermedia.** Post-abdomen.
16. **Pleuroxus hastatus.**
17. **Leptorhynchus falcatus.**
18. **Phrixura rectirostris.** Post-abdomen.
19. **Eurycercus lamellatus.** First foot of female.
20. **Alona sanguinea.** Shell markings.

Monospilus tenuirostris Fischer.

21. Lateral view.
21a. Head seen from in front.

Figures 19 to 21 original, others from Kurz, P. E. Mueller and Schoedler.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EXPLANATION OF PLATE LXIII.

FIG.

1. **Alonopsis latissima.** Male.
2. **Alona glacialis?** Female.
3. " **glacialis?** Male.

Alona glacialis (?) var. **tuberculata.**

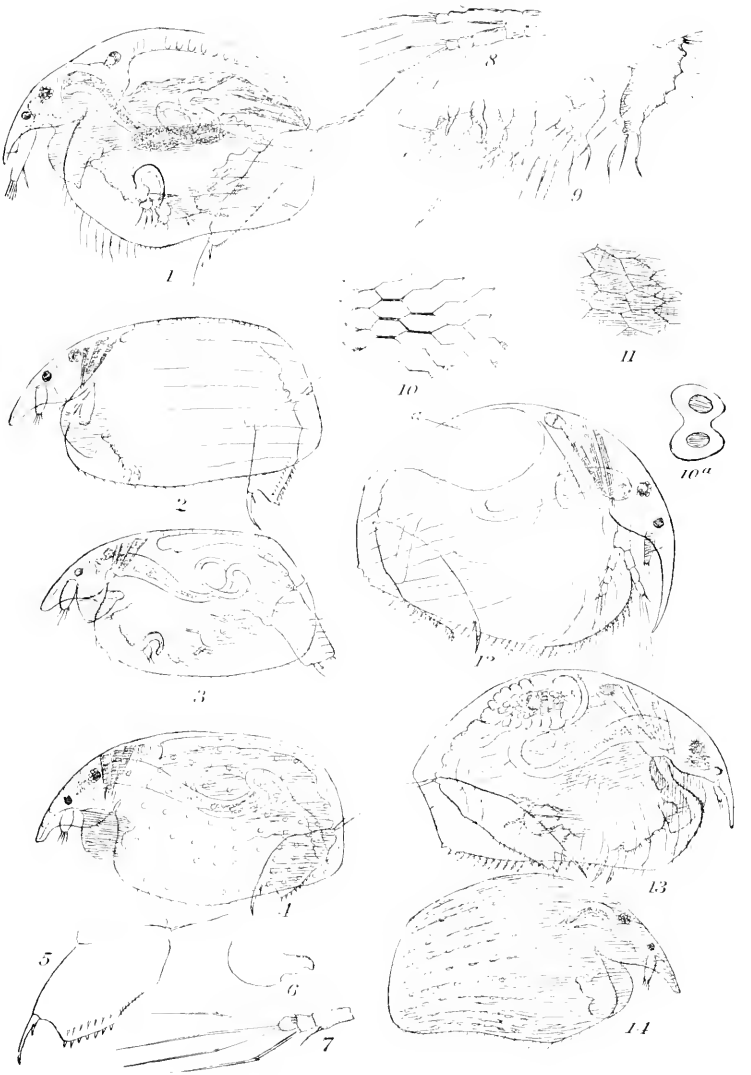
4. Lateral view.
5. Post-abdomen.
6. Labrum.
7. Antenna, setose branch.
8. **Alona glacialis.** Antenna.
9. **Alonopsis latissima.** Feet.

10,11. **Alonella excisa.** Details of shell sculpture.

Pleuroxus denticulatus.

10a. Outline of ephippium.
12. Female.
13. Common variety.

14. **Alona glacialis** (?) var. **tuberculata.**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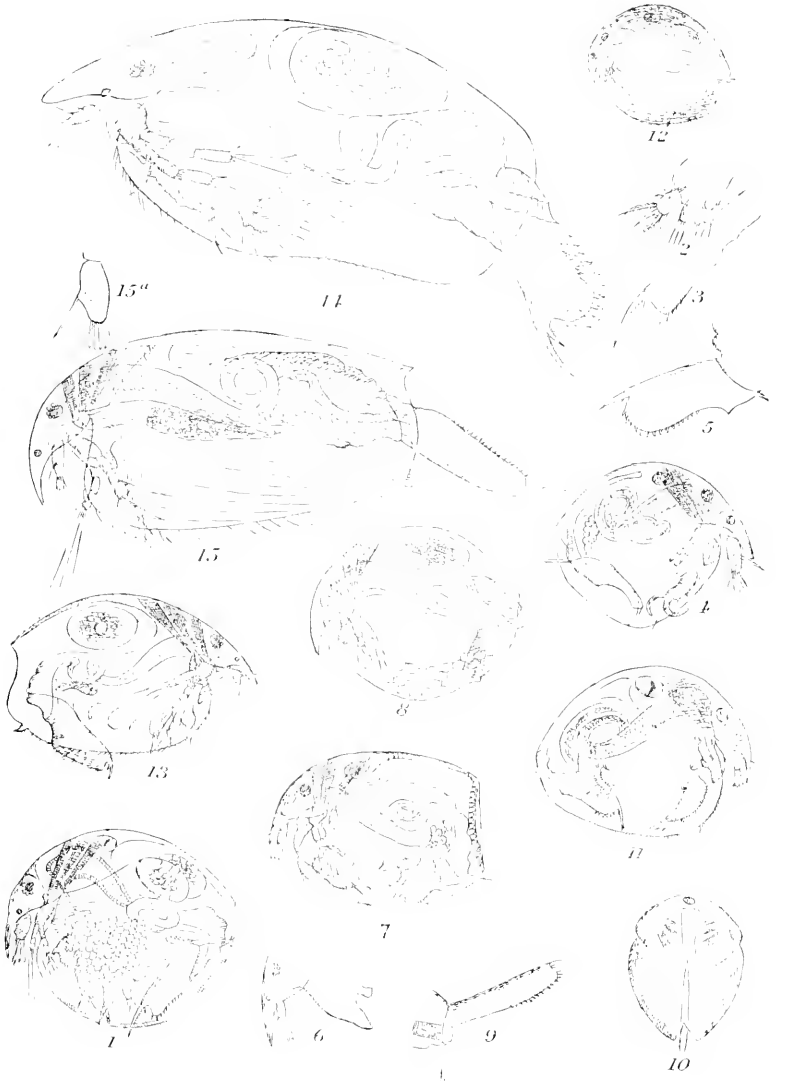
EXPLANATION OF PLATE LXIV.

Chydorus globosus.

Fig.

1. Side view.
2. First foot.
3. End of post-abdomen.

4. **Chydorus sphæricus.** Post-abdomen of male.
5. " **nitidus.** Post-abdomen of female.
6. " **nitidus.** Head.
7. " **sphæricus.** Ephippial female.
8. " **sphæricus.** Female.
9. " **globosus.** Post-abdomen of male.
10. " **sphæricus.** From above.
11. " **ovalis.**
12. " **cælatus.**
13. **Dunhevidia setiger.**
14. **Alona affinis.**
15. **Pleuroxus gracilis.**
15a. " **gracilis.** Antenna.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EXPLANATION OF PLATE LXV.

FIG.

1. **Bosmina striata.**
2. " **longirostris.**
3-5. " **cornuta.**
6, 7. **Pleuroxus procurvus.**
8. **Graptoleberis testudinaria** (var. **inermis**).
10. **Acroperus** sp.
11, 12. **Graptoleberis testudinaria** (var. **inermis**).

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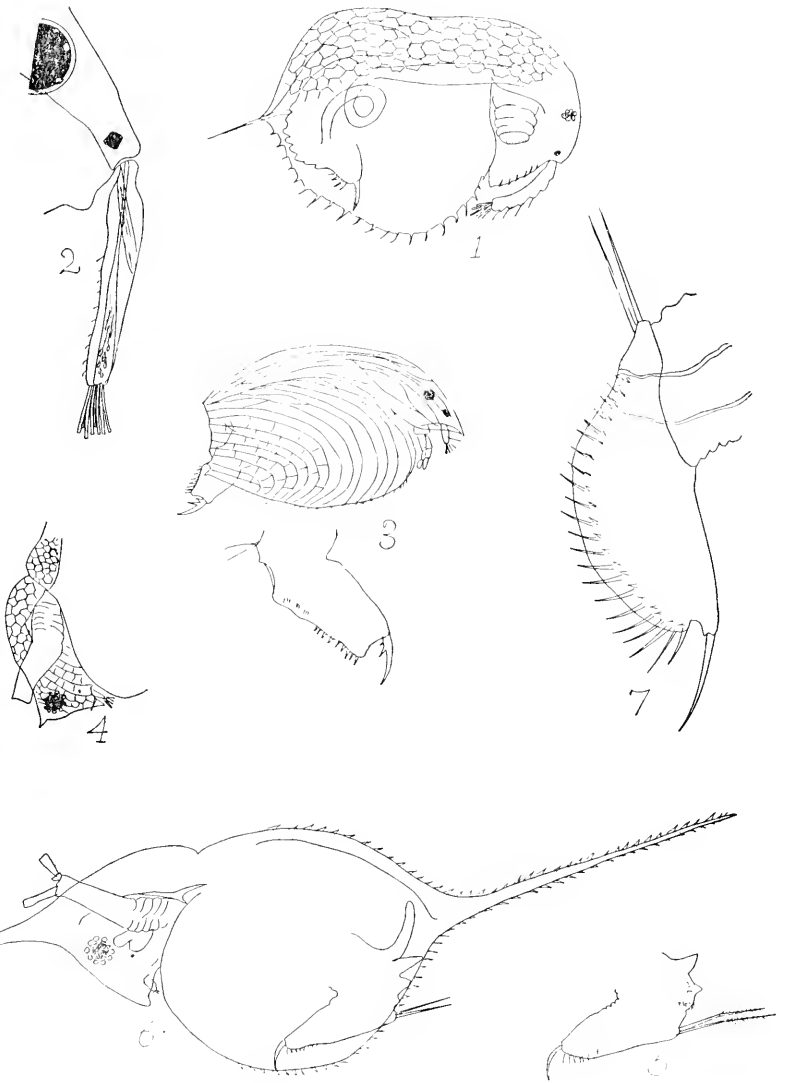
EXPLANATION OF PLATE LXVI.

Fig.

1. **Streblocerus serricaudatus.** Female.
2. **Macrothrix borysthenica.** Antennule.
3. **Pleuroxus griseus.** Female and post-abdomen.
4. **Ceriodaphnia cornuta.** Head.
5. Post-abdomen of same species.
6. **Daphnia lumholtzii.** Female.
7. **Leydigia australis.** Post-abdomen.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EXPLANATION OF PLATE LXVII.

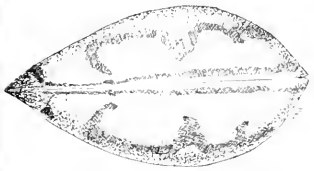
Cypris herricki.

FIG.

1. Dorsal view.
2. Lateral view.
3. One of the first pair of antennæ.
4. One of the second pair of antennæ.
5. Mandible.
6. First maxilla.
7. Second maxilla.
8. First foot.
9. Second foot.
10. Post-abdomen.

Cyprinotus crena.

11. Lateral view.
12. Mandible.
13. Feet.



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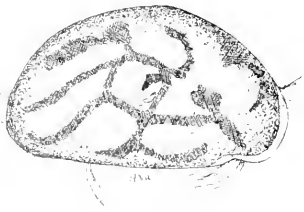

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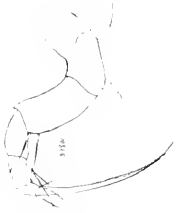

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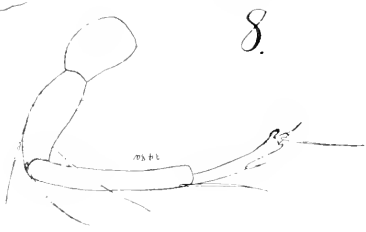

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EXPLANATION OF PLATE LXVIII.

Cypria inequivalva.

FIG.

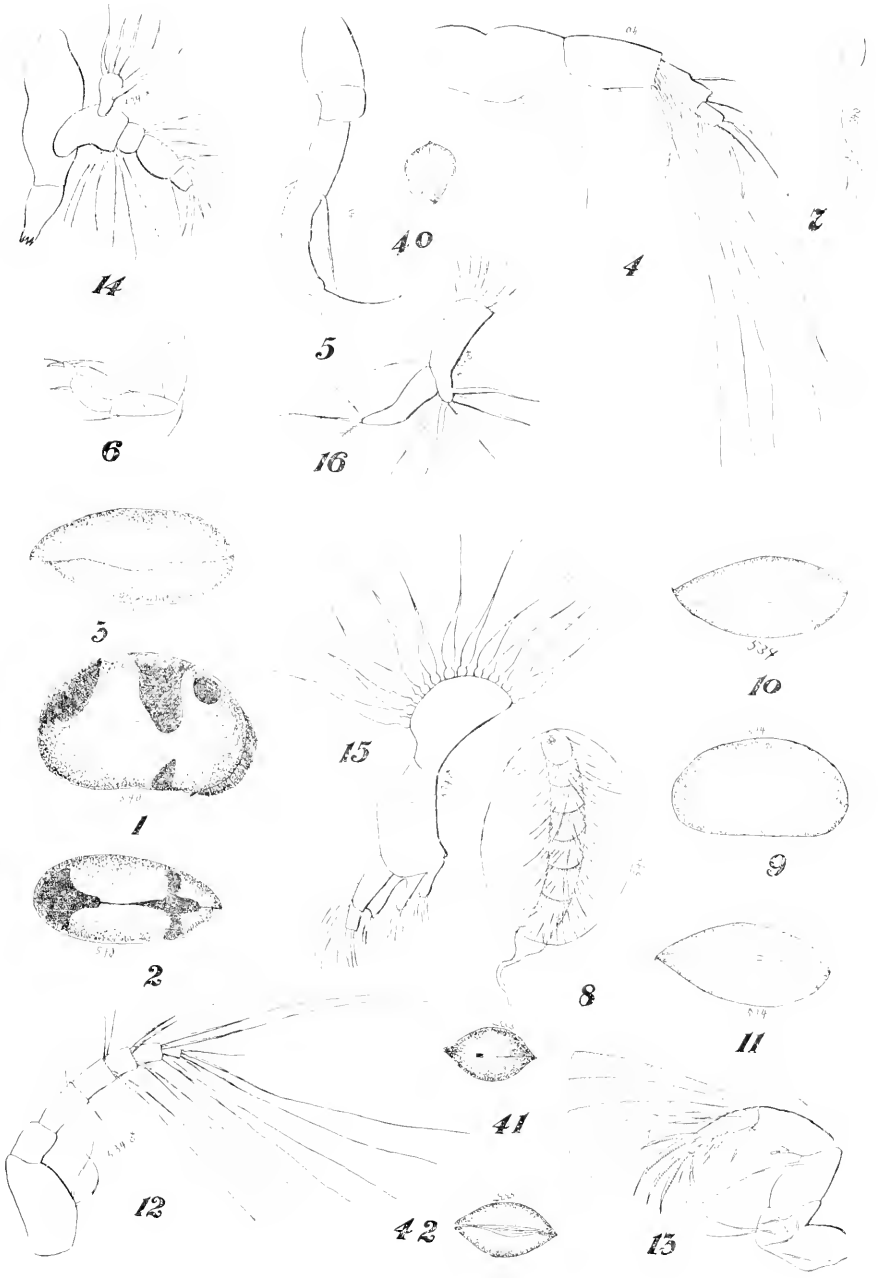
1. Lateral view, female.
2. Dorsal view, female.
3. Ventral view, female.
4. Antenna, female.
5. First foot, female.
6. Second foot, female.
7. Abdominal ramus.
8. Verticillate sac.

Cyprinotus incongruens.

9. Lateral view.
10. Dorsal view, female.
11. Ventral view, female.
12. Antennule, female.
13. Antenna, female.
14. Mandible, female.
15. First maxilla, female.
16. Second maxilla, female.

Cypris herricki C. H. Turner.

40. Larval stage A, end view.
41. Larval stage A, dorsal view.
42. Larval stage A, ventral view.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EXPLANATION OF PLATE LXIX.

Cypris incongruens Ramdohr.

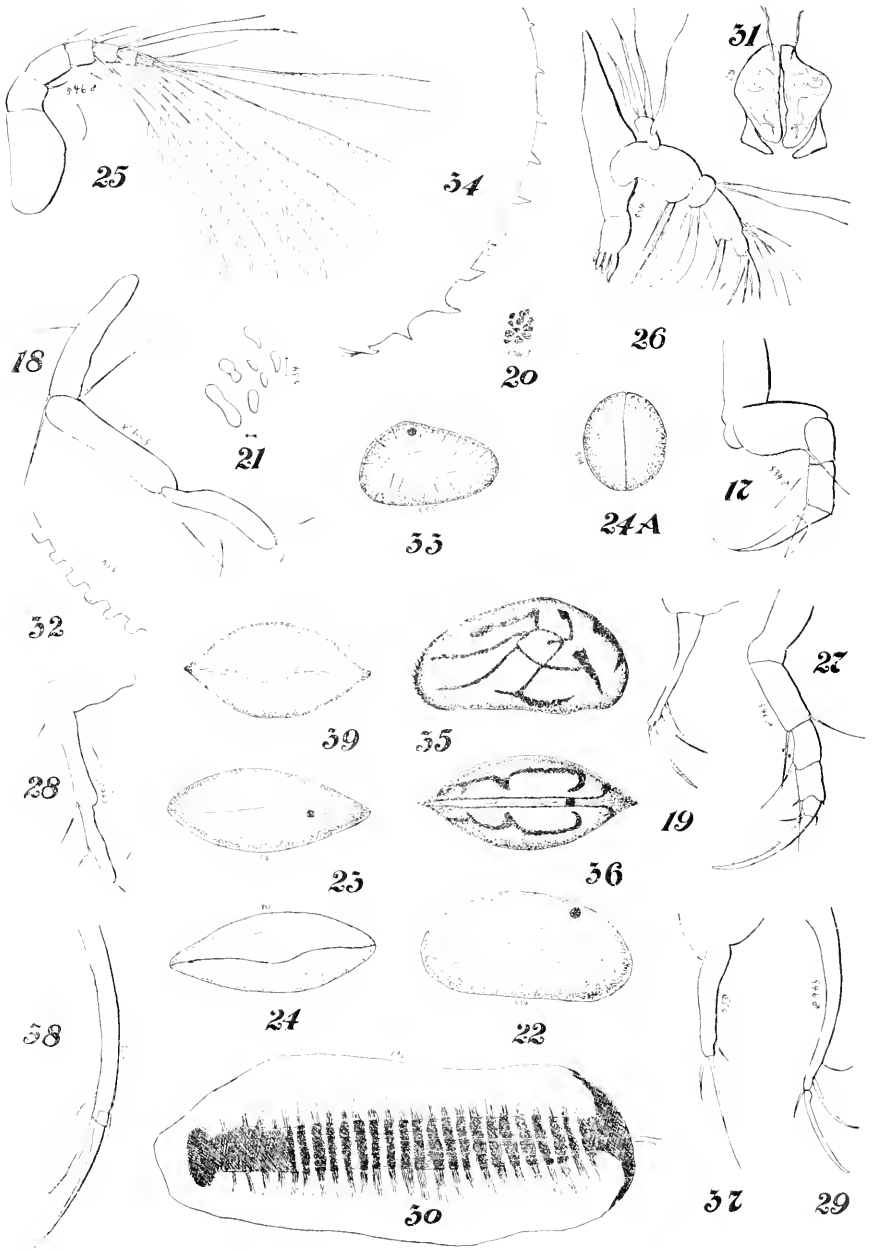
FIG.
17. First foot, female.
18. Second foot, female.
19. Post-abdomen, female.
20. Portion of shell.
21. Lucid spots.

Cyprinotus crena.

22. Lateral view, female.
23. Dorsal view, female.
24. Ventral view, female.
24A. End view, female.
25. Antennule, male.
26. Mandible, female.
27. First foot, male.
28. Second foot, male.
29. Post-abdomen, male.
30. Verticillate sac, male.
31. Copulative organ, male.

Cypris Herricki C. H. Turner.

32. Portion of ventral margin of shell, female.
33. Stage A, lateral view.
34. Stage A, teeth on caudal margin of shell.
35. Stage B, lateral view.
36. Stage B, dorsal view.
37. Stage A, post-abdomen.
38. Stage B, post-abdomen.
39. Stage B, ventral view.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EXPLANATION OF PLATE LXX.

Cypria exculpta Fischer.

FIG.

1. Lateral view of the shell of a young specimen.
2. Second foot.
3. Lateral view.
4. First foot.
5. Shell markings.
6. Antenna.
7. Post-abdomen.
8. Second maxillæ of male.

Cyclocypris lævis Müller.

9. Antenna.
10. Post-abdomen.
11. Second foot.

Cyprinotus burlingtonensis Turner.

14. Antennule.
15. Bit of shell.
16. Tip of first maxilla.
17. Dorsal view. (Fig. marked 692, middle of plate.)
18. Mandible.
19. Post-abdomen.
20. Antenna.
21. First foot.
22. Lateral view.
23. Second foot.

Figures 12 and 13 have been cut out.

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EXPLANATION OF PLATE LXXI

Candona crogmani Turner.

FIG.

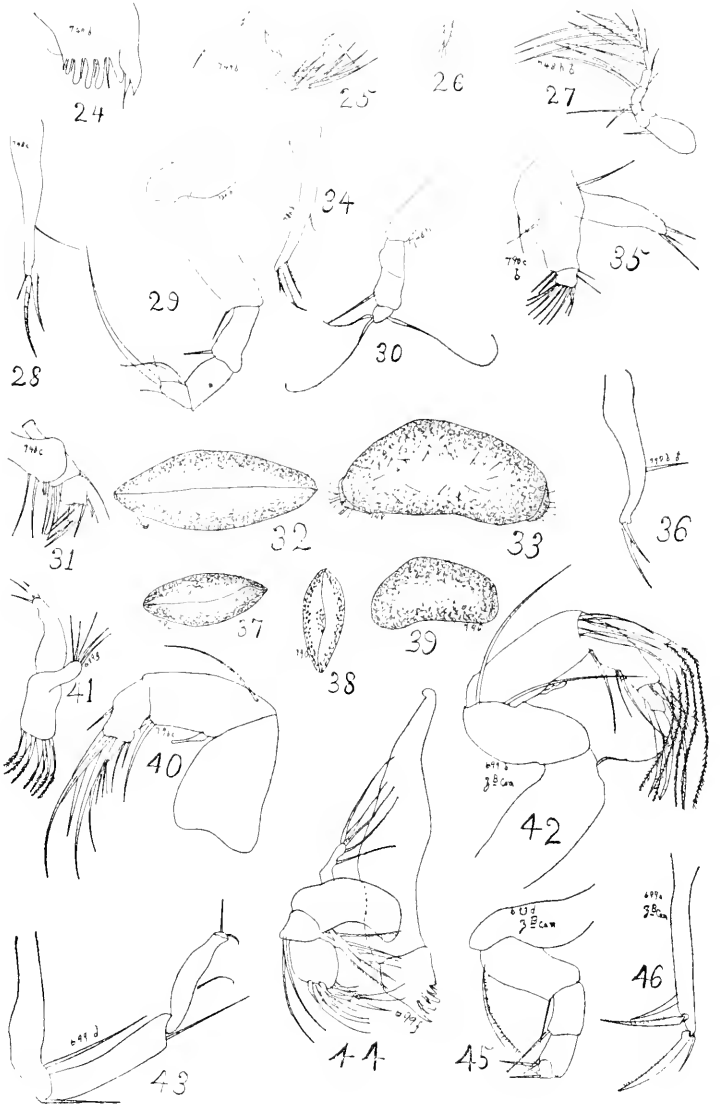
24. Mandibular teeth.
25. Antenna.
26. Sensory seta from mandibular palp.
27. Antennule.
28. Post-abdomen.
29. First foot.
30. Tip of second foot.
31. Mandibular palp.
32. Dorsal view.
33. Lateral view.
34. **Candona acuminata** Fischer. Post-abdomen.

Candona delawarensis Turner.

35. First maxilla.
36. Post-abdomen.
37. Dorsal view.
38. Ventral view.
39. Lateral view.
40. Antenna.

Cypris fuscata Jurine.

41. First maxilla.
42. Antenna.
43. Second foot.
44. Mandible.
45. First foot.
46. Post-abdomen.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EXPLANATION OF PLATE LXXII.

Cypridopsis vidua.

FIG.

1. Female from above.

1a. Antennule; 1b, antenna; 1c, first foot; 1d, second foot; 1e, mandible; 1f, maxilla; 1g, labrum.

Erpetocypris minnesotensis.

2. Female from side.

2a. Antennule; 2b, second antenna; 2c, first foot; 2d, second foot; 2e, mandible; 2h, abdominal ramus.

3. **Cypria exculpata.** Lateral view.

4. **Notodromas monacha.** 4d, second foot; 4f, second maxilla; 4f,[1] second maxilla; 4h, post-abdomen.

Cyclocypris modesta.

5. Male from side.

5*. Female from side.

5a. Antennule; 5b, antenna; 5c, first foot; 5h, abdominal ramus; 5x, copulative organ.

Cypridopsis newtoni.

6. Side view of female.

6*. Anterior and posterior margins.

6a. Antennule; 6b, antenna; 6c, first foot; 6f, maxilla; 6y, lucid spots; 6h, abdominal ramus.

Cypris fuscata.

7. Side view. Female.

7*. Dorsal view.

7b. Antenna; 7d, second foot; 7h, abdominal ramus; 7y, lucid spots; 7p, a magnified portion of the anterior margin of the shell.

Figures drawn by C. L. Herrick. Alabama Crustacea.

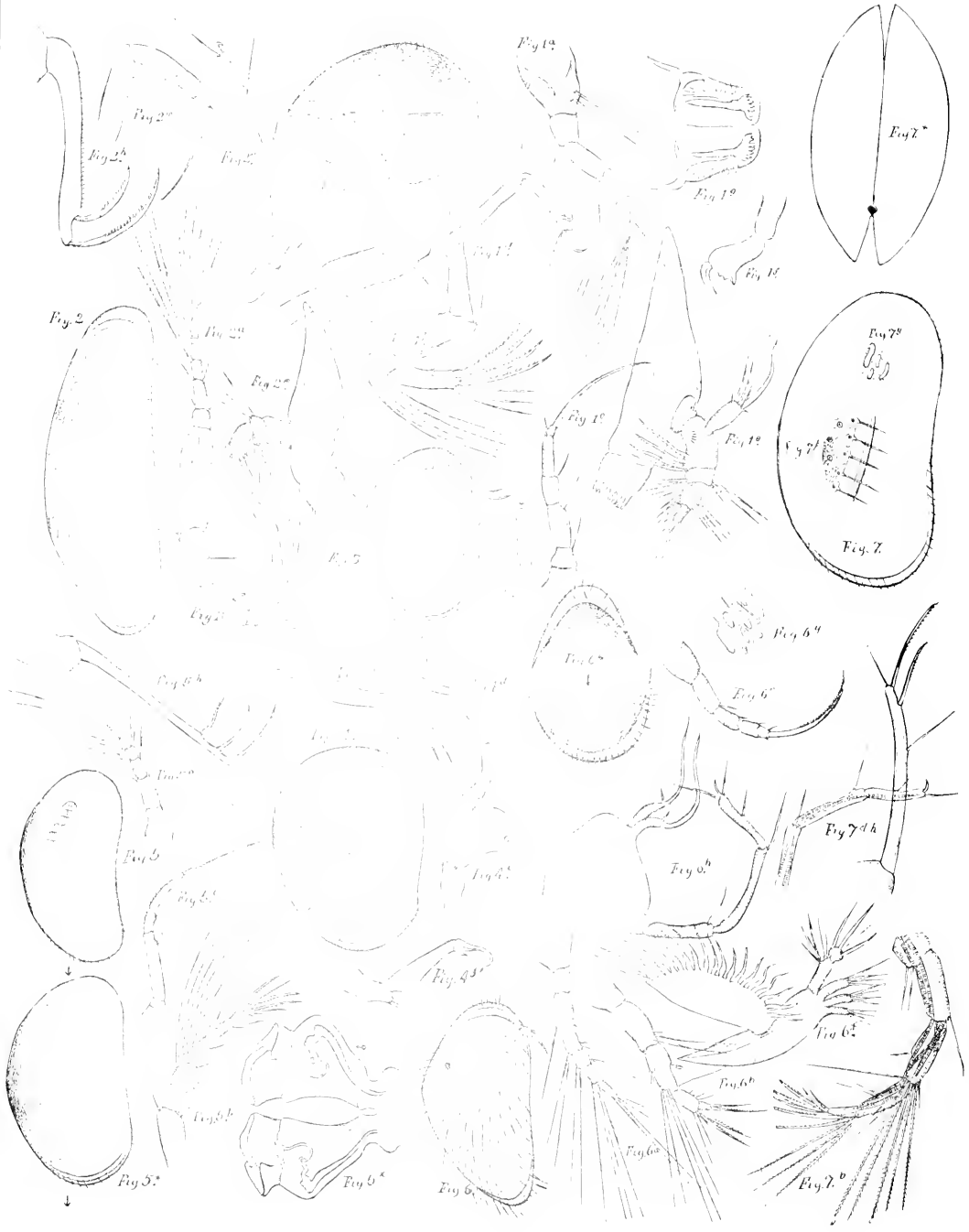
Fig. 1a
Fig. 1b
Fig. 1c
Fig. 1d
Fig. 1e
Fig. 1f
Fig. 1g
Fig. 2
Fig. 2a
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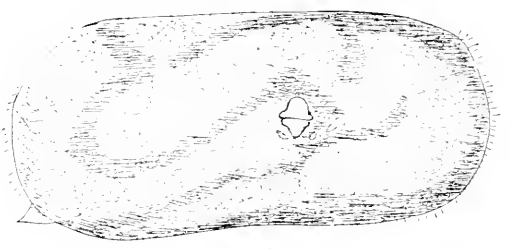
Fig. 2c
Fig. 2d
Fig. 2e
Fig. 3
Fig. 4
Fig. 5
Fig. 5a
Fig. 5b
Fig. 5c
Fig. 6
Fig. 6a
Fig. 6b
Fig. 6c
Fig. 6d
Fig. 6e
Fig. 6f
Fig. 6g
Fig. 6h
Fig. 7
Fig. 7a
Fig. 7b
Fig. 7c
Fig. 7d
Fig. 7e
Fig. 7f
Fig. 7g
Fig. 7h

EXPLANATION OF PLATE LXXIII.

Cypris perelegans

FIG.

1. Lateral view.
2. Dorsal view.
3. Labrum.
4. Jaw.
5. Abdominal ramus.
6. Natural size.



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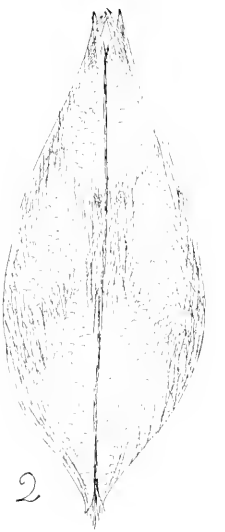

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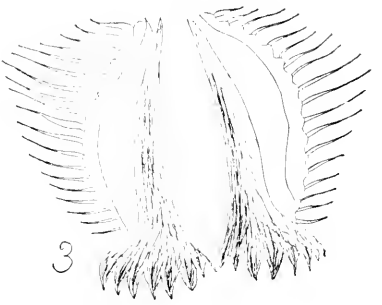

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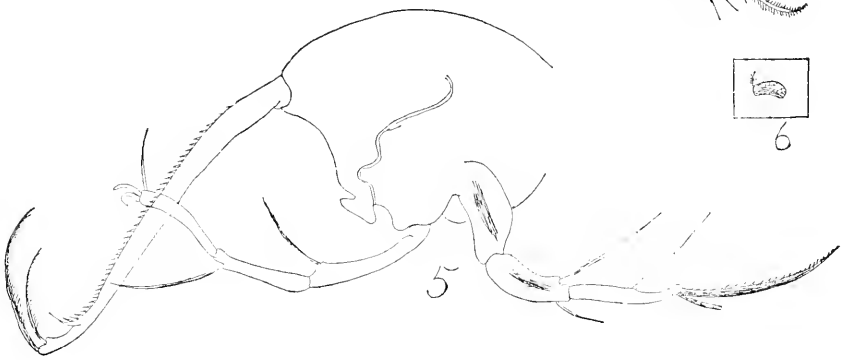

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EXPLANATION OF PLATE LXXIV.

Cypris virens (Jurine.)

FIG.

3. Labrum and both pairs of maxillæ.
a. Second antennæ.
b. First foot.
c. Second foot.
d. Jaws.
e. Caudal stylets.

The following figures of this plate are not noticed in the text:

1. **Gammarus dubius** Herrick.
2. **Streptocephalus sealii** Ryder.
4. **Harpacticus chelifer** Mueller.
5. **Laoponte mississippiensis** Herrick.
6. **Canthocamptus mobilensis** Herrick.

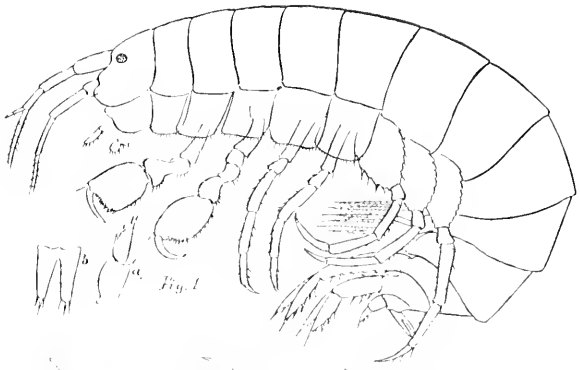


Fig. 1

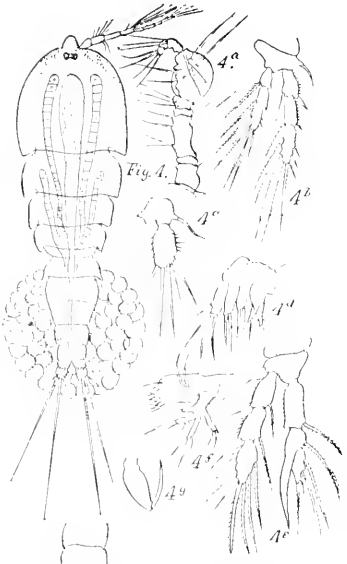
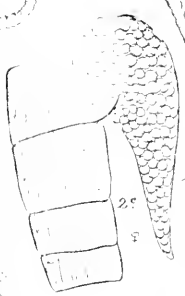


Fig. 4.

Fig. 2.



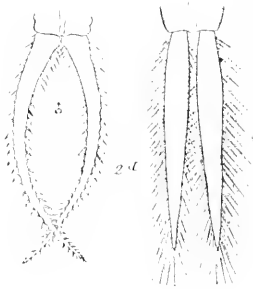


Fig. 6.

Fig. 5

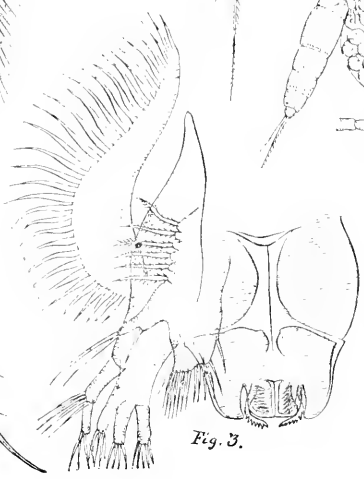
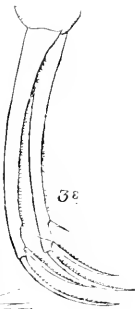


Fig. 3.



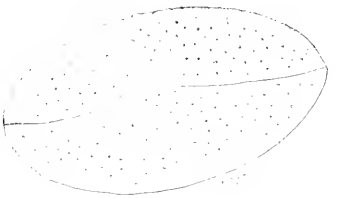
EXPLANATION OF PLATE LXXV.

Cypria opthalmica (Jurine).

FIG.

1. Ventral view.
2. Lateral view.
3. Dorsal view.

4. **Cypris.** Dorsal view.
5. **Cypridopsis vidua.** Lateral view.
6. " **vidua.** Ventral view.
7. **Cypria opthalmica.** End view.
8. **Cypridopsis vidua.** Dorsal view.
9. " **vidua.** End view.
10. **Candona fabæformis.** Dorsal view.
11. " **fabæformis.** Lateral view.



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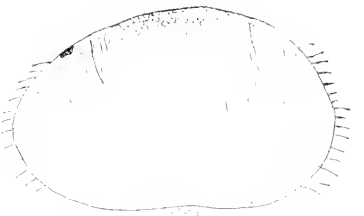

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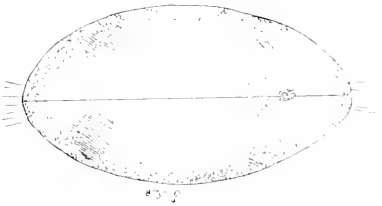

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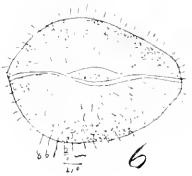

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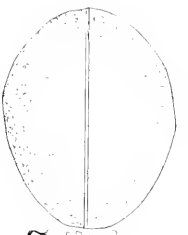

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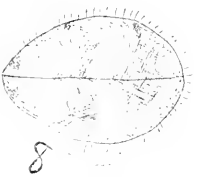

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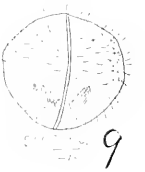

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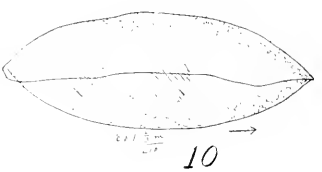

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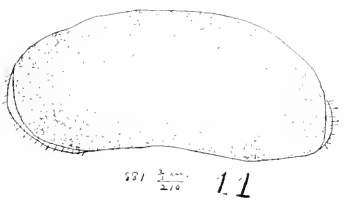

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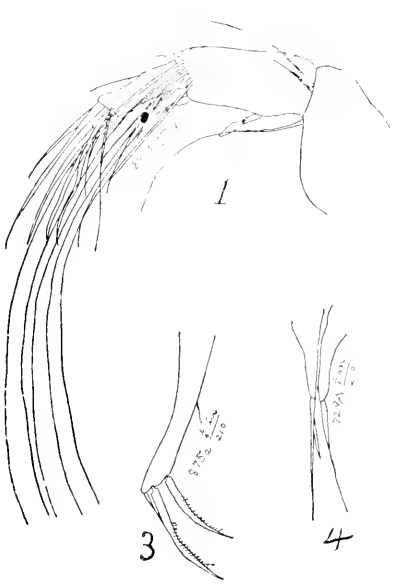
EXPLANATION OF PLATE LXXVI.

Cypria opthalmica.

Fig.

1. Antenna.
2. Second foot.
3. Abdominal ramus.

4. **Cypridopsis vidua.** Abdominal ramus.
5. **Cypria opthalmica.** Mandible, gill missing.
6. **Candona fabæformis.** Antenna of female.
7. **Cypridopsis vidua.** Antenna.
8. **Candona fabæformis.** Abdominal ramus.
9. **Cypris fuscata.** Muscle scars.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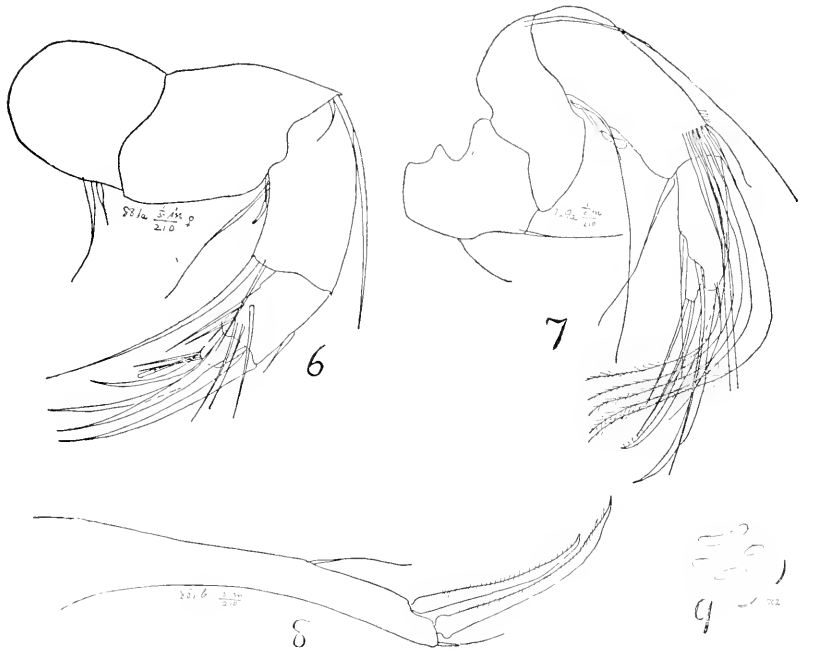
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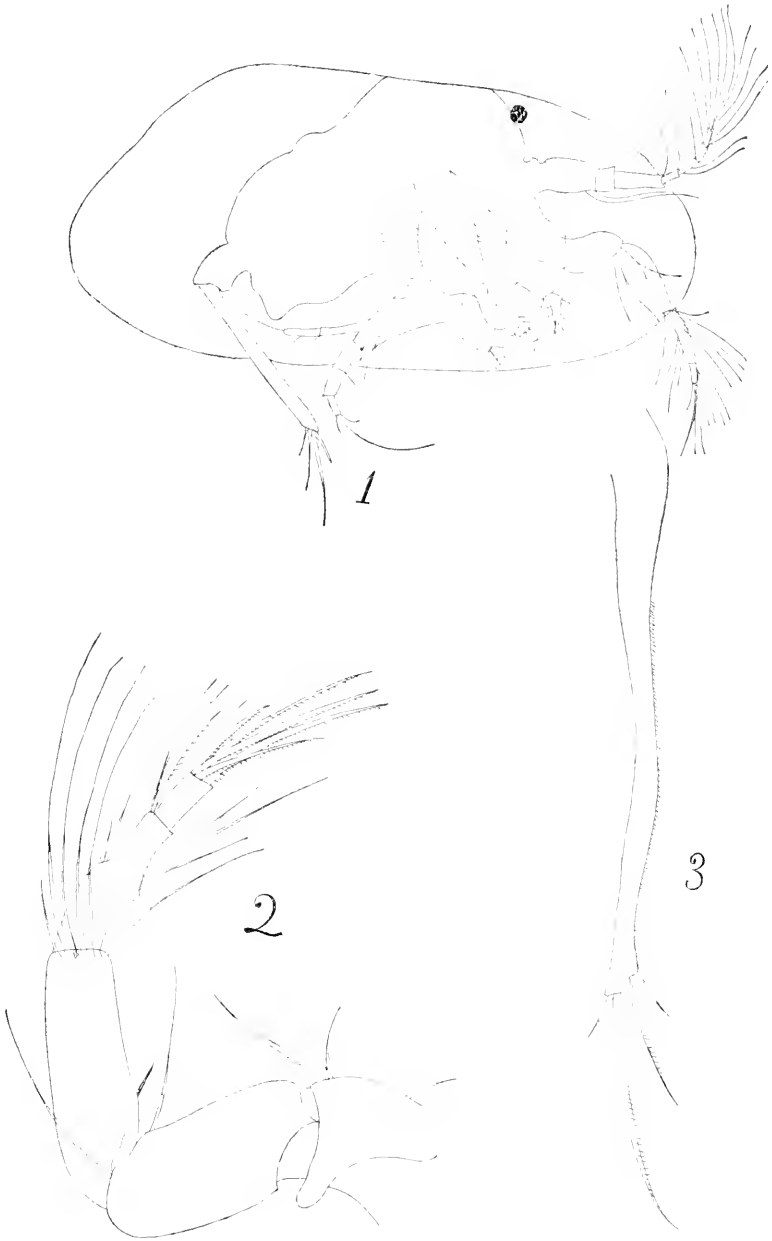
EXPLANATION OF PLATE LXXVII.

Erpetocypris barbatus.

FIG.

1. Lateral view.
2. Antenna.
3. Caudal ramus.

This plate is copied from S. A. Forbes.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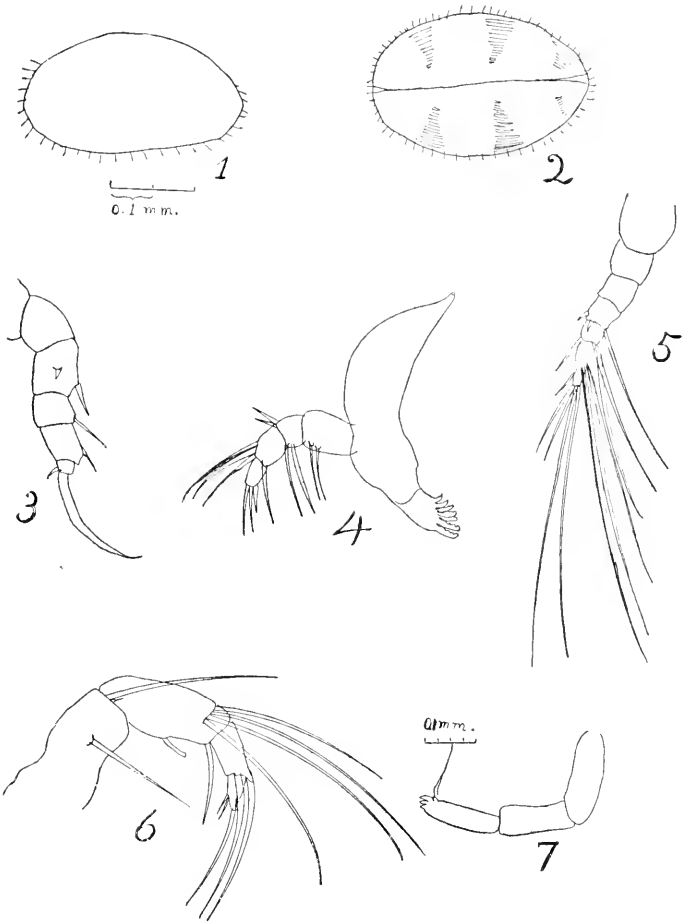
EXPLANATION OF PLATE LXXVIII.

Cypris albuquerquensis.

FIG.

1. Lateral view.
2. Dorsal view.
3. First foot.
4. Mandible.
5. Antennule.
6. Antenna.
7. Second foot.

The figures on this plate were made by Professor C. L. Herrick.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EXPLANATION OF PLATE LXXIX.

Cyprinotus grandis.

FIG.

1. Dorsal view.
2. Lateral view.
3. Palp of first maxilla of male.
4. First foot.
5. Second foot.
6. Mandible.
7. First maxilla of male.
8. Abdominal ramus.
9. Antenna.

Cypris altissimus.

10. Second foot.
11. Muscle scars.
12. Antenna.
13. Abdominal ramus.

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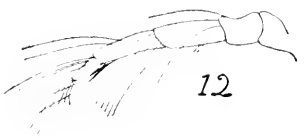

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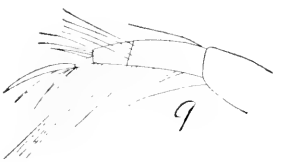

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EXPLANATION OF PLATE LXXX.

Candona peircei n. sp.

FIG.

1. Antenna of female.
2. Antennule of female.
3. Antenna of male.
4. Second maxilla of male.
5. Lateral view of male.
6. Ventral view.
7. Second maxilla of male.
8. Lateral view of female.
9. Abdominal ramus of male.
10. Copulative organ of male.
11. Abdominal ramus of male.

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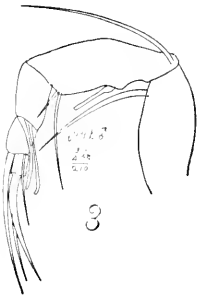
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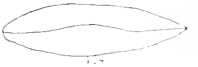
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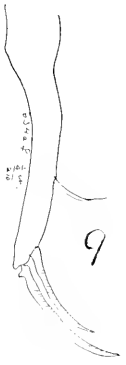
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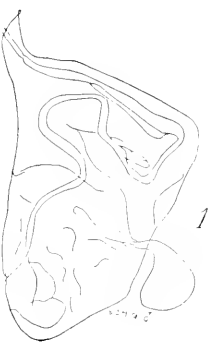
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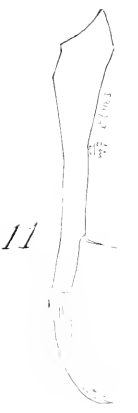
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EXPLANATION OF PLATE LXXXI.

Darwinula improvisa n. sp.

FIG.

1. Antennule of male.
2. Tip of second foot of male.
3. Antenna of female.

Candona crogmani.

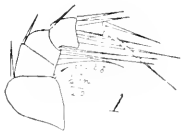
4. Palp of second maxilla of male.
5. Palp of second maxilla of male.

Cypria mons Chambers.

6. Dorsal view.
7. Lateral view.
8. Antenna.
9. Tip of first foot.
10. Lucid spots.
11. Second foot.
12. Abdominal ramus.

13. **Darwinula inopina.** Tip of first foot.

Figures 6 to 12 are copied from Chambers.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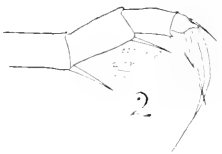
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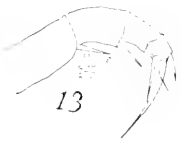
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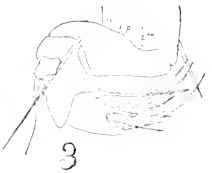
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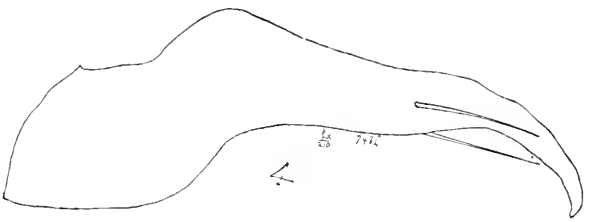
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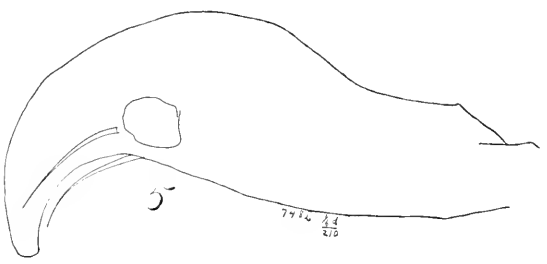
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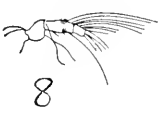
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INDEX

INDEX.

The figures in boldface refer to the page on which is found the description or "key" of the species or group.

The figures within parentheses refer to the plates.

The author's "Alphabetical Index of Species of Cyclops" (a list of synonyms) has been incorporated with the index.

The table of contents (page iii) shows the families and other groups considered in the report arranged under their respective orders.

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